A meeting every science teacher should attend; The Annual Convention of the Central Association of Science and Mathematics Teachers, November 23 and 24 at the Edgewater Beach Hotel, Chicago.

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XLV NOVEMBER, 1945 WHOLE NO. 397

OUR 1945 CONVENTION

WALTER H. CARNAHAN, *President*

The convention will be held.

The dates: November 23 and 24.

The place: Edgewater Beach Hotel, Chicago.

Restrictions: All restrictions on conventions have been removed.

The war and consequent necessary restrictions have created many problems for those responsible for planning the 1945 convention. Planning was difficult, and plans once made had to be changed more than once. But now the war is over, restrictions on conventions are removed, and plans are complete. Last month The Journal carried a brief statment about the program. The Yearbook should reach you soon after November 1 so that you can read the programs and other information in detail.

About Travel. There is no rationing of travel accommodations, and there are no orders prohibiting travel on public conveyances. Of course, military needs must be met whether or not you and I are accommodated, but indications are that at the time of our convention, trains and busses will be able to take care of all who wish to travel. Thanksgiving is a stay-at-home holiday in America, and travel at that time should be lighter than at other times. Gasoline is unrationed and back to pre-war quality. Travel by automobile is your best means of going to the convention.

About The Hotel. Edgewater Beach is one of Chicago's finest hotels. Its facilities for our meeting are near perfect. Ours will probably be the only convention meeting at the hotel at

Thanksgiving time, so there should be accommodations for all. But you are urged to make reservations early, just to be sure. See your Yearbook for the schedule of prices.

Have you ever stopped to figure up what it costs a hotel to arrange for a convention such as ours? On Friday afternoon we ask for eight of their largest and best rooms for our meetings, we ask for janitorial service, we ask for heat, we ask for hundreds of chairs to be placed according to our needs. If we should rent these rooms and pay for this service, the bill would be several hundreds of dollars. The headquarters hotel gives all this free. The only returns they realize are on the meals they serve and the rooms they rent. Our continued use of hotel accommodations for our conventions depends upon our patronage of the headquarters hotels.

How To Reach The Edgewater Beach Hotel. If you drive, get on Chicago's Outer Drive and go north until you come to the hotel about three miles up the lake. If you take the bus, get on a north bound bus marked "Sheridan Road 51." This will take you to the main entrance of the hotel. Elevated trains north will take you within three blocks of the hotel. If you take a taxi, just say, "Edgewater Beach Hotel."

Never in the history of America have scientists and mathematicians and teachers of science and mathematics been held in such high esteem as they are to day. This is one of the results of the war and our contributions to its successful conclusion. Let us now prepare ourselves to maintain this position in peace times. Central Association can help you and me in this respect. Plan to attend the Chicago convention.

THE ATOMIC BOMB

A General Account of the Development of Methods of Using Atomic Energy for Military Purposes under the Auspices of the United States Government is the title of a pamphlet written by H. D. Smyth, Chairman of the Department of Physics of Princeton University and Consultant to Manhattan District of U. S. Corps of Engineers, for sale by the Superintendent of Documents, Government Printing Office, Washington 25, D. C. The price is 35 cents. This gives as much of the story of the atomic bomb as can be told at the present time. Professor Smyth states: "The average citizen cannot be expected to understand clearly how an atomic bomb is constructed or how it works but there is in this country a substantial group of engineers and scientific men who can understand such things and who can explain the potentialities of atomic bombs to their fellow citizens." This pamphlet has been prepared for this professional group of citizens.

ADA WECKEL

After a short illness, Miss Ada Weckel, long time active member of the Central Association of Science and Mathematics Teachers, died on July 10th, 1945. She had retired from teaching in the Oak Park and River Forest High School at the end of the 1943–44 school year.

After coming to Oak Park in 1909, Miss Weckel took an active interest in the affairs of the Association, serving on various committees, as chairman of the Journal Committee, as secretary and in 1929 as president of the Association. She has contributed to the welfare of the Journal, SCHOOL SCIENCE AND MATHEMATICS, and has been a regular attendant at conventions up to the time of her death. She took great pleasure in meeting and encouraging younger teachers along their way and was an inspiration to the many who had contact with her at Association meetings.

Miss Weckel was a leading figure at the high school through her 35 years of association there, offering wise council to faculty and pupils alike. In 1912, she was made head of the biology department and in 1923 was made dean of freshman girls, in which capacities she served until her retirement. Intensely interested in her subject, she was the author of a text book on general science, one of the earliest, which was widely used. Another outcome of her keen thinking was a system of animalkins which she originated for the study of biology in class rooms. During her many years as dean, she was beloved by the girls and by the parents.

Active in the life of the community, Miss Weckel was a charter member and a former president of Zonta Club. She was a member of the P. E. O. sisterhood, the League of Women Voters and chairman of the social science department of the Nineteenth Century Woman's Club.

Born in Moline, Illinois, Miss Weckel received her Bachelor's degree from the University of Michigan and her Master's degree from the University of Chicago. Before going to Oak Park, she taught in the St. Louis, Missouri schools. She was active in the affairs of the American Association for the Advancement of Science, and a member of the Illinois and National Education Associations.

Ada Weckel will long be remembered by the members of the Association and her influence will be felt for years to come.

HAROLD H. METCALF

A VITAMIN DEMONSTRATION RELATIVE TO ABSORPTION

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Many phases of the science dealing with nutrition, as taught in the high school biology course, are suitable for demonstration, illustration, or experimentation. Let us first note easily ascertainable data or procedures: (1) Digestive organs may be observed and studied, both internally and externally, by dissecting a recently anesthetized dog secured from a pound. (2) By chemical analysis we determine the composition of foods. (3) Food values have been compounded and are available in class chart form. (4) The action of enzymes are demonstrable. (5) Literature may be secured pertaining to diets, calories, vitamins, minerals, and the use of nutrients. There are, however, aspects of the digestive processes which are abstract to secondary students. Consequently, they are little understood by them. Here, reference is made to the time involved between ingestion and assimilation of the various foods. Recently, a series of questions was raised, relative to these processes, in the writer's biology class. Specifically, the students asked, "How soon after we have eaten does digestion and absorption begin?" Again, "How much time is required for this material to reach the cells?" Other queries could be quoted, but the trend of the inquiry is sufficiently indicated. The class was composed of intelligent young men. Among them, are many who will, someday, be science teachers, engineers, chemists, and doctors. Therefore, a vague or general answer would be inadequate and, in addition, would be challenged. The questions offered two important opportunities; namely, (1) They centered around a fundamental life process. Therefore, student interest should be fostered and encouraged to obtain first hand information about the human body, and (2) the questions had an appropriate basis for experimentation.

Owing to our limited research facilities, we are aware that if our questions are to be answered or partially answered, our problem was to find something which, following ingestion, would produce effects recognizable through the senses. Obviously, the commonly eaten foods, such as vegetables, milk, and meat were not suitable for our purpose.

Previously, we had studied the different classes of nutrients

and the digestive organs and processes by which each was reduced to soluble end products. Likewise, it had been pointed out that water and vitamins could be absorbed as such. Through a search of scientific literature, we learned that Nicotinic Acid Amid produced symptoms which could be observed. Using this information as a focal point, our discussion centered around the planning of activities leading to an understanding of our problems. Accordingly, we proceeded as follows:

1. We examined the inner membrane of a dog's intestine. The students were aware of the myriads of protuberances or villi through which absorption was partially accomplished. Following the examination, absorption was thoroughly discussed.

2. To demonstrate the speed of a fluid passing through a permeable membrane, the familiar osmosis demonstration with an egg, graduated glass tube, sealing wax, and water was used.

3. Having determined the methods our body uses to accomplish absorption, we were ready to study the time elapse between swallowing a Nicotinic Acid tablet and the resulting symptoms. The vitamin tablets which we secured were of a 100 mg. potency. This, it may be noted, is a high potency.

Procedure and Results

The individual, who had volunteered for the experiment, was instructed not to eat breakfast the morning of the demonstration. He was asked to report to the class room several minutes in advance of the regular class time. This gave his organ systems a chance to return to a nearly normal rate of functioning. The subject sat quietly facing the class. His face, neck, arms, and part of his chest were exposed for observation. Both a subjective and an objective analysis of symptoms were made, as follows:

1. After thirteen minutes—prickling sensations were reported in the hands and forehead.
2. Sixteen minutes—the first symptom was visible to the observers. This consisted of a slight flushing of the face.
3. Seventeen to twenty-five minutes—a pronounced flushing was observed covering the face, neck, arms, and chest.
4. Twenty-seven minutes—the subject had the desire to scratch his arms and neck.
5. Twenty-nine minutes—symptoms began to diminish. Flushing fading and prickling sensations reduced.
6. Thirty-two minutes—prickling sensations were gone.
7. Thirty-seven minutes—only a slight flush remained.
8. Forty-two minutes—all symptoms had disappeared.

No one could be more conscious than the writer, that the results we obtained, significant as they were, fell short of giving a complete understanding of our original questions. For example, we learned nothing regarding time elapse between ingestion and assimilation of proteins, carbohydrates, fats, and mineral salts. However, our experiment had been directed toward a single objective.

THE KURILES AND THE RYUKYU ISLANDS

With the Kurile islands again in the hands of Russia, together with Sakhalin, the Sea of Japan will no longer be a private Japanese lake, and the coast of Siberia, on the Sea of Okhotsk, Tatary gulf and the Japan sea, can be given adequate strategic protection. The 32 important islands in the Kuriles stretch some 700 miles from northern Japan to Kamchatka, and are so spaced that passage through them can be easily blocked.

Many of the Kuriles were fortified by the Japs, and several had airfields. The condition in which these military objects are at the present time is not generally known. The many American air attacks on them from Aleutian-based and carrier planes probably badly damaged the Jap fortifications on Paramoshiri, near Kamchatka peninsula, and did considerable damage on islands farther south.

The Kuriles were Russian until they were ceded, under pressure, to Japan in 1875. The Japs renamed them Chishima, which means "the myriad islands." In addition to the 32, there are many others of smaller size. Kurile comes from the Russian word "kurit," meaning to smoke, an appropriate name, as the islands have several smoking volcanoes. The Japanese designation, Chishima, will now probably disappear.

The loss of these islands, which contain over 6,000 square miles of land, will be an economic as well as a military blow to the Nipponese. They contain large quantities of merchantable timber, some agricultural and grazing land, and wild game, including furbearing animals, and they are surrounded with excellent fishing waters.

The loss of the Ryukyu islands, south of Japan, is also a military and economic blow that Japan will keenly feel. This string of islands, that stretch from southern Kyushu to Formosa, guards the entrance from the Pacific into the East China sea and from there into the south entrance through the Strait of Korea into the Sea of Japan.

Their economic value was largely for the production of foodstuffs. Although volcanic, with some areas of considerably high elevation, they are warmed by the ocean currents from the south and produce some semitropical foods that Japan needs.

The Ryukyu archipelago is Japanese by aggression, but was annexed to the Nipponese empire prior to 1895. The future control of these islands has not yet been determined. Once independent, then Chinese, they have been definitely Japanese since 1879, although the Nips had collected tribute from them for many years, having invaded them first in 1609. China objected to their inclusion in the Nipponese empire up until 1905, when the Japs took Formosa. China may now ask that they become again a part of the Chinese nation.

THE FUNCTION CONCEPT IN THE SOLUTION OF PROBLEMS OF ELEMENTARY ALGEBRA

JACOB M. KINNEY
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INTRODUCTION

The function concept in its elementary phases coincides with the idea of interdependence of quantities. That is to say, the function concept in elemetary algebra implies the dependence of one variable quantity upon one or more variable quantities. The idea of dependence of one variable quantity upon one, or more variable quantities, is one which is fundamental in science, in business, in engineering, and in agriculture. All of these fields are examples of the function concept in action.

Elementary algebra which is supposed to prepare pupils for functional thinking in more advanced courses in mathematics and for courses in science should be a model of functional thinking. But at the present time twenty-five years after the report of the National Committee on the Reorganization of Secondary School Mathematics (1920) and five years after the Report of the Joint Commission of the Mathematical Association of America and the National Council of Teachers of Mathematics on the Place of Mathematics in Secondary Education (1940), we still find in a large number of texts excessive emphasis placed upon manipulation and but little emphasis on that phase of elementary algebra, namely, functional thinking, which should be in evidence on almost every page of the text.

As I have pointed out, the function concept implies relationships between variable quantities. Here are two terms, quantity and variable, which are of fundamental importance. These two terms must be stressed and used to the extent that the pupil thoroughly understands their meaning.

QUANTITY

To clarify the meaning of quantity the teacher should point out that such words as length, area, volume, value, weight, time, temperature, height, depth, and the like, are expressions of quantity; and should explain that these are terms which are associated with number. For example, when the grocer asks: "How many pounds of sugar do you want?" and you answer "Five": you are associating the number five with the quantity weight. Again, the statement, "I walked 5 miles today" implies

that the number 5 is associated with the quantity distance. In fact, we may think of quantity as being anything that may be represented by a number. It should also be noted that a quantity may be expressed by more than one number. For example, the quantity, 5 pounds, may also be expressed as 80 ounces, or .0025 ton.

An extended exercise should be devised for clarification of this fundamental idea of quantity. In this exercise should be found such questions as the following: To what quantities do the following terms belong: 6 feet tall, 100 miles from this place, 10 cubic feet, and 35°. Is the quantity 90 square feet the same as the quantity 10 square yards? Express the quantity 5 miles in terms of rods and also in terms of yards.

Variable Quantity

We now have the problem of clarifying the concept of variable quantity. The teacher should point out that algebra, like arithmetic, is concerned with quantities; that algebra uses the same signs of operation: but unlike arithmetic in that we may use a letter to represent a set of numbers. To illustrate: let T mean "Number of degrees of temperature at 6 o'clock A.M. each day for one week as indicated in Table 1."

Table 1

Day	Sun	Mon	Tues	Wed	Thurs	Fri	Sat
T	41°	54°	59°	64°	57°	55°	52°

Here, the letter T stands for 7 different arithmetic numbers. Its value varies from day to day. Thus T represents a variable quantity. Sometimes it is convenient to call T a variable. Much attention must be given to the new concept. Such questions and problems as the following may be presented.

If y means "number of days in a year," what are all possible values of y?

If w means "number of days in a week," what are all the possble values of w? Is w a variable quantity in this case? If not, what is it?

If m means "number of days in a month," how many different values does m have? What are the values of c in a c-cent piece?

If y means "number of yards" in the length of a line, what is

the numerical value of y, if the length of a line is: 1 inch? 1 foot? 1 yard? 1 rod? 1 mile?

What are the values of N, if N means any even number between 1 and 13? What are the values of N, if N represents any number divisible by 3 and lying between 2 and 20?

What are the values of f, if f is a fraction whose numerator is one of the numbers 1, 3, and 5 and whose denominator is one of the numbers 2, 4, and 6? Arrange the values of f in the order of size. How many fractions are there?

A boy has 5 coins of which some are nickels and some are dimes. Let c mean "number of cents." What are the possible values of c?

Let n mean an integer like 1, 2, 3, . . . How can we express in cents the value of n 3-cent stamps? How can we express in cents the sum of n 2-cent stamps and n 3-cent stamps?

Ratio

At this point it is appropriate to introduce the idea of ratio as an expression of relationship between two like quantities and to note that in this case the ratio is a fraction either common or decimal. To review this concept such questions as the following may be asked. Is the ratio of 2 to 3 equal to the ratio of 24 to 36? Of $2k$ to $3k$? What is the ratio of two lines whose lengths are respectively 2 feet 6 inches and 4 feet 2 inches? What is the ratio of the length of the first of two lines to that of the second, if the first is a inches long and the second is a feet long?

In a certain class there were two pupils who received the mark A; six, the mark B; eleven, the mark C; five, the mark D; and one, the mark F. Find the ratio of the number in each grade class to the total number in the class. Express each ratio in per cent.

Representations of Relationship

There are four forms in which we may express relationships between variable quantities: namely, by tables, by graphs, by formulas, and by verbal statements. A simple type of correspondence, or relationship, between variable quantities is fur-

Table 2

6 A.M.	8 A.M.	10 A.M.	12 M.	2 P.M.	4 P.M.	6 P.M.
65°	69°	75°	78°	82°	76°	72°

nished by tables. Thus, in Table 2 we find a correspondence between the temperature recorded for the even hours from 6 A.M. to 6 P.M.

We have here a definite relationship between the numbers representing time and the numbers representing temperature.

In many scientific investigations data are collected in the form of tables. For an example on the level of ningth grade students let us set up the following problem: namely, to determine the relation between the elongation of a spiral spring and the force applied to it. This may be accomplished by suspending the spring from a support and placing weights on a pan at the lower end. After having determined the normal length of the spring in inches, let us place in the pan in turn weights of 1 ounce, 2 ounces, and so on to obtain the following table, in which *w* means "number of ounces" and *e* means "number of inches" in the elongation of the spring.

TABLE 3

w	1	2	3	5	8	10	16
e	.3	.6	.9	1.5	2.4	3.0	4.0

If the teacher permits the class to report on their observations, she will probably get the following information.

(a) The table shows that there is a relationship between the weight and the elongation.

(b) If the weight is doubled, the elongation is doubled; if the weight is trebled, the elongation is trebled; and so on.

(c) the ratio e/w for each number pair has the value .3; and thus for each ounce added, the elongation is increased by .3 inch.

If we let the symbol (w, e), in which we think of e as depending on w, represent any number pair in Table 3, and let e/w be the ratio of any number pair, then Table 4 shows clearly that

TABLE 4

w	1	2	3	5	8	10	16
e	.3	.6	.9	1.5	2.4	3.0	4.8
e/w	.3	.3	.3	.3	.3	.3	.3

while w and e vary over their respective sets of values, the ratio e/w does not change. Thus we may put this relation in the form

$e/w = .3$, which is equivalent to $e = .3w$. This equation is the formula for this particular spring. If we replace .3 by the constant k, we have the general formula, or law, $e = kw$, which expresses the relationship between the elongation of a spiral spring and the force applied.

If we construct the graph of Table 3 and translate the formula into a verbal statement we then have the four forms in which the relationship between two variables may be expressed.

Direct Linear Variation

The equation, $e = .3w$, is a special case of the general form, $y = ax$. If we write this variation in the form $y/x = a$, it is clear that if x is multiplied by a constant k, then y must be multiplied by k. This type of relationship between two variables, namely, in which the function is equal to the product of a constant and the variable, is called a direct linear variation.

If $y = ax$ is satisfied by the number pairs (x_1, y_1) and (x_2, y_2), respectively, we obtain the equations $y_1 = ax_1$ and $y_2 = ax_2$. If we divide the members of the first equation by the corresponding members of the second equation, we obtain the proportion $y_1/y_2 = x_1/x_2$, or $y_1/x_1 = y_2/x_2$. For this reason, the equation, $y = ax$, is sometimes expressed in the form "y is proportional to x."

The direct linear variation is a fundamental form. A great deal of attention should be given to this relationship by setting up linear tables, constructing the graphs of the tables, finding the corresponding equations, and translating the latter into verbal statements.

As bases for problem material involving direct linear variation, I append Table 5 and Table 6 with appropriate directions for a class exercise. In Table 5 we find data based on an experiment with an elastic cord. We let w mean "number of grams" and E "number of centimeters" in the corresponding elongation.

Table 5

w	5	10	15	20		30	
E	.8	1.6	2.4		4.0		5.6

(a) Complete the table.

(b) The table shows that as the ______ increases the elongation ______.

(c) If the weight is doubled, the elongation is ______.
(d) If the weight is multiplied by 3, the elongation is ______.
(e) The number pairs in the table are (5, .8), (   ), . . .
(f) What is the common ratio of the number pairs?
(g) Construct the graph corresponding to the table.
(h) The equation corresponding to the table and the graph is ______.
(i) Write a verbal statement corresponding to the equation.

In Table 6 let p mean "number of dollars" in a principal and i, the "number of dollars" of interest.

TABLE 6

p	25	50	100		300
i	1.50	3.00		13.50	

(a) Complete the table.
(b) The number pairs are (   ), . . .
(c) The ratio of each number pair, that is, i/p, is ______.
(d) The rate of interest is, therefore ______ per cent.
(e) What is the formula corresponding to the table?
(f) Write the verbal statement corresponding to the formula.

TRANSLATION

The ability on the part of the pupil to translate a verbal statement into a formula, and conversely, to translate a formula into a verbal statement is one that is highly desirable. I have already indicated exercises which lead the pupil to the generalization that a letter may represent any one of a set of numbers. If he has attained the ability to make this generalization, he is ready to translate verbal statements into formulas, and conversely.

The following examples are given for illustration.

(a) The distance traveled by an automobile at a constant rate of 30 miles per hour is obtained by multiplying the number of hours by 30. (d, t). Write the formula corresponding to this statement.

Solution. Let d mean "number of miles" and t, "the number of hours," then $d=30t$.

A statement may be put in a form that cannot be translated directly. In that case we rearrange it or restate it.

(b) In an alloy of copper and zinc there are 64 pounds of copper to 15 pounds of zinc. (z, c).

Solution. This statement means that the ratio of the number of pounds of copper to the number of pounds of zinc is 64/15. Thus, $c/z = 64/15$, or $c = (64/15)z$.

In translating a formula into a verbal statement the teacher should insist that the pupil use precise and elegant language. It is not a literal translation, but one of ideas, that is desired.

(c) In the formula, $p_7 = .12 + .10(w-1)$, p_7 means postage on a parcel addressed to a point in the seventh zone and w means the number of pounds in the weight of the parcel. Translate.

Solution: The postage on a parcel addressed to a point in the seventh zone is 12 cents for the first pound and 10 cents for each additional pound.

Characteristic Formulas[1]

There are thousands of formulas to be found in handbooks, in books on science, engineering, and business. These formulas vary in complexity from the simple linear type, $y = ax$, to the exceedingly complicated algebraic forms involving radicals and powers, and various other types of functions. The letters used in these formulas are usually the initial letters of significant words found in the verbal statement of the formula. To give a simple example: the formula $F_g = MM'a/d^2$ is a statement of the law of universal gravitation for two masses in which a is the unit of attraction. The initial letters found in this formula make it easy to characterize the relationship between the elements, namely, force, mass, and distance, which are involved in this situation. For this reason we call such formulas characteristic formulas.

There are many formulas which express direct linear variation. Such formulas are special cases of the abstract linear equation $y = ax$. We shall find that many of these formulas are useful in solving verbal problems. I list a few examples for reference.

$d = rt$ (distance, time, constant rate)
$p = rb$ (percentage on a base at constant rate)
$W = rt$ (work done at constant rate)
$C = cN$ (Total cost at cost c per unit)

Evaluation

The process employed in finding the value of one variable when the value of a related variable is given is called evaluation of the variable. In the linear relation, $y = ax$, in which x and y

[1] See *The Teaching of Elementary Algebra* by Paul Ligda, Houghton Mifflin Company, Boston.

are the variables and a is a known constant, we may have the problem of finding y if x is given or of finding x if y is given. If a is unknown, we can determine its value if the variables are known. To illustrate let us solve the following problems.

(a) After a flash of lightning it was 11 seconds before the sound of thunder was heard. If the speed of the sound was 1090 feet per second, how far did the sound travel?

Solution. The characteristic formula is

$$d=rt$$

$$r=1090,\quad t=11$$

$$d=1090\cdot 11$$

$$d=2.4 \text{ miles.}$$

(b) Find the diameter of a tree whose circumference is 14 feet and 8 inches.

Solution. The characteristic formula is

$$c=\pi d$$

$$c=44/3, \text{ let } \pi=22/7$$

$$44/3=(22/7)d$$

$$d=4 \text{ ft. and } 8 \text{ in.}$$

(c) An agent sold a farm for $12,260. His commission was $245.20. What was his rate of commission?

Solution. The characteristic formula is

$$p=rb$$

$$b=12{,}260,\quad p=245.20$$

$$245.20=12{,}260r$$

$$r=02, \quad \text{or} \quad 2\%.$$

Rate

The problems in the section on evaluation may also be used to call the attention of the pupil to the quantities involved and their particular relationship which we call the rate. This relationship is expressed explicitly if we divide each member of the equation $d=rt$ by t to obtain $d/t=r$. If d is expressed in miles and t in hours, the rate r is expressed in terms of the quantity "miles per hour." The number of "miles per hour" is r.

From the percentage formula, $p=rb$, we obtain $r=p/b$. If both p and b are numbers which express values in terms of dol-

lars, then r, the rate, is the number of dollars per dollar. Returning to the problem (c) above in which $b = \$12{,}260$ and $p = \$245.20$, we find

$$r = \$245.20/\$12{,}260$$
$$= .02 \text{ dollar per dollar.}$$

In the case in which the quantities are alike, it is customary to write the rate as an abstract number, as indicated in the section above.

Problem Solving

Many of the quantitative problems we meet in practical affairs are stated in words. They are often stated in a form which does not express explicitly the relationships existing between the variables. To add to the difficulty they may be expressed in technical terms.

The problems with which we are now concerned belong to the very simple type in which there are two variables of which one varies directly as the other, and in which there may be one or more situations. The problems in the section on evaluation belong to the type in which there is but one situation.

As examples of problems involving two situations let us consider the following.

(a) Two trains are leaving a station 320 miles apart. They are traveling toward each other at the average rates of 50 miles per hour and 30 miles per hour, respectively. In how many hours will they meet?

In this problem we have two situations, one for each train. Each situation is characterized by the uniform motion formula, $d = rt$. We solve the problem by the following plan.

Fast train	Slow train
$d_1 = r_1t_1$	$d_2 = r_2t_2$
$r_1 = 50$	$r_2 = 30$
$d_1 = 50t_1$	$d_1 = 30t_2$

We see now that we need more relationships to solve the problem. These relationships may be secured by noting that

$$d_1 + d_2 = 320$$
$$t_1 = t_2 = t.$$

Therefore,

$$50t+30t=320.$$

Thus,

$$t=4.$$

(b) How much water must be evaporated from 50 gallons of a 6 per cent solution of salt water to obtain 8 per cent solution of salt?

Solution. The characteristic formula is $p=rb$.

Let $w=$ the number of gallons of water to be evaporated.

6 per cent solution	8 per cent solution
$p_1=r_1b_1$	$p_2=r_2b_2$
$r_1=.06$	$r_2=.08$
$b_1=50$	$b_2=50-w$
$p_1=3$	$p_2=4-.08w$

Implied relationships

$$p_1=p_2$$

Hence,

$$3=4-.08w$$

$$w=12.5.$$

The following simple work problem furnishes an example of three situations.

(c) A farmer can plow one of his fields with a team of horses in 120 hours. His neighbor can plow it with his tractor in 24 hours. If they work together, in how many hours can they plow the field?

The characteristic formula is $w=rt$.

Horses	Tractor	Combination
$w_1=r_1t_1$	$w_2=r_2t_2$	$W=RT$
$t_1=120$	$t_2=24$	$T=?$
$w_1=120r_1$	$w_2=24r_2$	$W=RT$

Implied relationships

$$w_1=w_2=W$$

$$r_1+r_2=R$$

$$W=120r_1 \qquad W=24r_2 \qquad W=RT.$$

Thus,

$$r_1=\frac{Q}{120}, \qquad r_2=\frac{Q}{24}, \qquad R=\frac{Q}{T}.$$

Since

$$r_1+r_2=R.$$

We have

$$\frac{Q}{120}+\frac{Q}{24}=\frac{Q}{T}$$

$$\frac{1}{T}=\frac{1}{120}+\frac{1}{24}$$

Thus,

$$T=20.$$

Abbreviated Solutions

In the solution of each of the problems I have exhibited the complete analysis. In whatever form the solution may be cast, we consciously or unconsciously recognize the various steps in the analysis. After a pupil has made analyses of problems as exhibited above, it is not necessary to set down all the steps in the solutions of other problems of the same types. For example, in Problem (a) the pupil may proceed as follows.

Let t = the number of hours after starting.

Then,

$$30t+50t=320$$

$$80t=320$$

$$t=4$$

WORKBENCH TOPS

Structurally wood has the tendency to warp and check under different climatic conditions. To overcome this, it is sawed into narrower strips and glued together. In this way, the tendency of the part to twist out of line is counteracted by the other parts glued to it. This is the reason tops of work benches are made of narrow strips glued together rather than one solid wide plank. When the wood fibres are cut through they can only contract and expand over a smaller area and the less the distance between the cuts, the less contraction and expansion, and therefore less warping. There is no loss of strength either. Joints made with animal glue for example have a tensile strength of better than 5000 pounds per square inch, twice as strong as wood itself.

SOME SUGGESTIONS FOR INDIVIDUALIZED WORK IN GENERAL SCIENCE AND BIOLOGY LABORATORIES[1]

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Most teachers will agree that it is contradictory to permit students to conclude that green plants produce O_2 in the presence of light on the basis of a single demonstration, and then, on the other hand, to challenge fallacious statements concerning race because these statements are made on the basis of inadequate evidence. Yet when science teaching becomes solely, or in large part, demonstration teaching, this is often the practice; students are all too frequently deprived of the opportunity for statistical validation of their hypotheses.

Pupils should be exposed to many experiences leading to identical observations and conclusions before a conclusion or a principle relating to these experiences is derived. It is desirable, therefore, that a teacher prepare, with pupil assistance when possible, many such experiences relating to a single principle.

Described in this paper are some suggestions which may be of use to teachers of General Science and Biology who wish to add to their repertoire of individualized laboratory procedures. The suggestions have been tested under classroom conditions and they have been chosen because their simplicity makes them readily adaptable to individual work. Credit for the source, when known, is given in the bibliography.

1. Diffusion

It is sometimes desirable to show not only that substances diffuse from a region of greater concentration to a lower concentration, but also to show something of manner in which this occurs.

A large test tube or other container is filled with water, a few drops of phenolphthalein (1% in alcohol) are added and some cellophane is fastened over the mouth of the tube with a rubber band. The tube is then inverted and the cellophane surface is placed on the neck of an opened bottle of concentrated ammonia. In less than a minute the ammonia gas will have diffused

[1] These demonstrations were given at the December 1944 meeting of the New York State Science Teachers Association at Syracuse.

through the cellophane, and the swirling pink-to-red color of phenolphthalein reactive to ammonium hydroxide will show the path of the diffusing ammonia.

It is instructive first to perform this demonstration without using phenolphthalein. To the question—"What is happening?"—many students will state that—"nothing is happening." After performing a second demonstration, using phenolphthalein, students will be ready to suggest a method for the detection of the diffusing ammonia in the first tube and to accept this as an instance of a method of science—namely, the use of valid tests to aid the eye where the latter alone is inadequate. "Seeing" in the commonly accepted sense, is not "always believing."

NOTE: Cheap cellophanes are best. Each student may do this in the classroom by inserting the phenolphthalein tube in a solution of Na_2CO_3, or dilute ammonia.

2. Nutrition

It is sometimes desirable to test for the presence of a vitamin, to make "quantitative" consumer studies of its presence in various foods, in different brands of the same food, in cooked and fresh samples of the same food, etc. A .1% stock solution of dichloro-benzenone-indophenol (ordered as a powder in gram quantities from Merck or Eastman Kodak) in water is prepared. This solution may be diluted for use with different types of foods. In the presence of vitamin C, the blue solution becomes white. In practice, it is best to use a specific quantity—2 to 5 cc. of the indophenol—and add the liquid or juice being tested drop by drop with a pipette. The number of drops of grapefruit juice necessary to turn the indophenol white may be compared with the required number of drops of milk, or vegetable water, or dilute tomato juice,—or with different brands of grapefruit juice, or canned and fresh juice, and fresh and cooked tomato juice.

NOTE: At least ten drops or so of the juice should be required to turn the indophenol white so that reasonably correct count may be made. Usually the food juices being tested need to be diluted to achieve the result. It is relatively easy to organize several days of individual laboratory work on this important phase of the work in nutrition.

(The following four suggestions form a series on the principle of "balance in nature.")

3. Respiration

It is sometimes desirable to demonstrate that air is changed

within the body, e.g. oxidation occurs within the body. The apparatus figured below is useful. Enough 1% bromthymol blue solution in water is added to tap water in the two Erlenmeyers or gas bottles to make the solutions a definite blue. The demonstrators—several students—inhale and exhale air by means of the Y-tube and force inspired and expired air to pass through one Erlenmeyer and out through the other as can be seen from the diagram. Expired air (containing a greater concentration of CO_2) will turn the blue solution in the exhalator yellow, while the bromthymol blue in the inhalator remains blue.

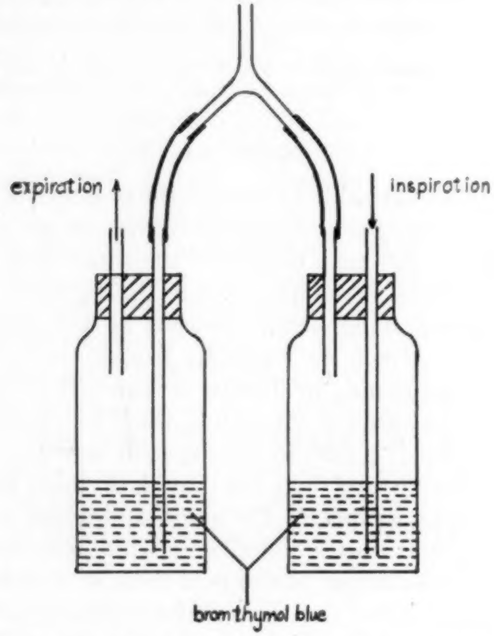

FIG. 1. Apparatus for showing that oxidation occurs within the body.

NOTE: This is an excellent device to show the nature of the "control experiment."

If a *Y* tube is lacking, the two rubber tubings may be placed in the mouth.

In order to turn the bromthymol solution a definite blue, a trace of NH_3 may be added to the indicator. If too much NH_3 is added, the indicator will turn yellow with great difficulty. (3)

4. Exercise on Oxidation

In order to demonstrate the effect of exercise on oxidation, it is simply necessary to prepare a sufficient quantity of dilute

NaOH or NH_4OH solution to which enough bromthymol blue (turns base blue) or phenolphthalein (turns base pink) are added to turn the solution distinctly blue or red. The concentration of the base should be high enough to need the effort of one minute or so of exhalation of expired air through the liquid to change it to yellow or white (by means of a straw). The student is then asked to skip rope, or run up and down the stairs for a minute or so. After exercise, the time necessary to turn the liquid is cut to $\frac{1}{3}$ to $\frac{1}{2}$ of the original time (4).

5. Absorption of O_2 and CO_2 by Blood

To show the effect of O_2 and CO_2 on blood, 30 cc. of blood is placed in each of two 100 cc. graduates or similar containers and O_2 and CO_2 is bubbled in from generators. The success of the demonstration depends on the placement of the mouth of the delivery tube on the bottom of the graduates so that bubbling of the blood is produced. The interfaces of the bubbles turn a distinct bright red in O_2 and a distinct maroon in CO_2. If the delivery tubes are interchanged, the change in color of the succeeding bubbles is quite marked.

Note: Blood may be obtained from slaughterhouses, if a permit is obtained. (5)

6. Photosynthesis

To show that green plants use CO_2 in the presence of light, just enough .1% bromthymol blue is added to a sufficient quantity of aquarium water to turn the latter a visible blue. It is desirable to use as little indicator as necessary. The solution is turned *just* yellow or yellowish-green by exhaling through the liquid by means of a straw. To one part of this bromthymol yellow aquarium water in a large stoppered test tube or similar container, several healthy shoots of Elodea or Cabomba are added. The control consists of the bromthymol yellow solution minus the plant. Within 30 to 50 minutes, in bright sunlight, the Elodea will absorb enough CO_2 to turn the bromthymol yellow to bromthymol blue, while the control is unaffected. In cloudy weather, a projection lantern or similar source of light, two feet away from the tubes will be useful.

On the other hand to demonstrate what happens in the absence of light, a bromthymol blue-aquarium water solution is prepared in test tubes and Elodea is added to one tube. Both tubes are then placed in the dark. The tube containing the Elo-

dea will turn yellow due to the respiratory activity in the Elodea. The control remains blue. (6)

NOTE: It is important to add as little bromthymol blue as is necessary. See note in number 3 for the preparation of the indicator. For this experiment it is especially necessary to use the smallest possible trace of NH_4OH. These "experiments" may be organized as individual laboratory exercises.

7. Dependence of Animals on Plants

To demonstrate the dependence of animals on plants, it is well to seal a plant and an animal in glass. A large test tube is pulled in a bunsen flame till a narrow neck (about $\frac{1}{2}$ inch) is produced. Aquarium water is poured into the lower chamber of the cooled tube and a small quantity of Cabomba, Utricularia or Nitella is pushed through the neck into the aquarium water. A small piece of chalk and a snail (Physa) are added. Then the neck is pulled out in the flame to capillary length, cooled to permit equalization of cool air, and then the capillary tube is quickly sealed. (7)

8. Difference in Environment

To show one effect of a difference in environment on an organism, a red-leaved Coleus plant may be divided into two approximately equal cuttings. The stems are placed in water. One plant is placed in sunlight, another in shade. After a few days, the leaves of the plant in sunlight remain a deep red, the leaves of the plant in the shade turn a distinct green, especially on the upper surface.

9. Constancy of Genetic Make Up

In order to demonstrate that the genetic make-up of an organism is constant throughout its entire body, the so-called Piggyback plant, or various varieties of Coleus may be used. From the former, many leaf cuttings and from the latter many stem cuttings may easily be made. The plants derived from each cutting will resemble each other, showing their similarity in genetic make-up. (9)

10. Germination, Tropisms, Hydroponics

A simple germinator, which will enable students to observe germination may be made as follows. A piece of blotting paper is placed so that it lines the inner surface of a test tube. Soaked seeds are placed between the blotter and the glass. The blotter is soaked with water.

This apparatus has other uses. If the tube is fixed in a clamp on a stand, it may be turned in all positions; the growing plant will show various tropistic responses. If solutions containing various salts, or varyingly concentrations of salts are placed in the tube so that the roots are wetted, the principles governing hydroponics may be observed. Certainly the nature of the early growth of the plant is readily observed.

11. Living Materials

Most teachers agree that the backbone of biology teaching is living material. Good sources of living materials, from the protozoa to the small mammals, such as rats and mice, are therefore of considerable importance. New York City has developed a group of Living Material Centers housed in various schools. Student culture and maintain these animals and distribute them free of charge to other schools in the city and state. From the first one started in 1938 by the writer, the movement has grown to include 10 schools organized under the efficient guidance of the Laboratory Assistants Association of N. Y.; no school need be without living materials. The methods used for the maintenance of the protozoa and other small invertebrates used have been described at length; (11) space cannot be taken here for reprinting. It is urged that other localities develop their own.

Protozoa: Several forms have been found to be more desirable than those commonly used. For instance, Blepharisma appears to be a form more easily identified by all students. It is pink so that it can be definitely identified and distinguished from contaminants. It moves slowly and has large ciliary structures (cirri) which can be easily seen under low power. It eats other large protozoa so that the food vacuoles are clearly distinguished and its large posterior contractile vacuole is almost diagrammatic. It is on the basis of preliminary investigation, far superior to Paramoecium.

Chaos chaos is, in a similar way, superior to Amoeba. Chaos is a large Amoeba, which sometimes reaches 5 millimeters or more in length. It can be detected with the naked eye; pseudopods can be seen with a good hand lens. Its functions and structure can be studied under low power. If it is fed Stentor or Blepharisma, its food vacuoles become blue or red. It may be readily cultured by the methods referred to above (11), (12).

However, if Paramoecium must be used, then it must be

slowed down for observation. Of the many substances suggested, methyl cellulose has been used by Marsland at Washington Square College, and has shown itself to be excellent for that purpose in the classrooms at Forest Hills. It may be dissolved in warm water to form a viscous solution which in proper consistency slows Paramoecium so that it may take two to five minutes to cross a low power field. The preparation of a solution of proper consistency is largely a matter of experience. The Dow Chemical Co. is the distributor for methyl cellulose (15). One drop of the viscous solution added to one or two drops of the culture on a slide is sufficient.

12. Dissectible Model of a Cell

It is sometimes desirable to show the three dimensional nature of a cell and to indicate the relationship of cell membrane, cytoplasm, and nucleus in "living" as well as in "stained" condition. For the former condition, a piece of white cellophane, as large as is desired, is formed into a bag and a warm solution of 2% agar-agar is poured so as to fill ½ of the bag. When this cools, a clear glass marble is dropped on the center of the agar, and more warm agar is poured over this marble to fill the bag. The bag is then tied with white thread and the ends of the cellophane above the thread are snapped off with scissors to make a ball like structure. In class, the cellophane peels off to simulate the plasma membrane, the agar-agar forms an acceptable gel-like, gray cytoplasm, and the marble the nucleus.

If a black or purple marble is used for the nucleus, and if a few drops of phenolphthalein and NaOH are added to the agar, then a dark nucleus in pink cytoplasm limited by an "invisible" plasma membrane, will simulate a cell stained in haematoxylin-eosin. (13).

13. Models

Most models used in Biology and General Science need not be purchased. They can be made by students who may use clay, plaster of paris, wood, papier-mache, and other media. These models are superior in one respect to commercial ones, in that they may be made to fit the particular learning situation. Elizabeth Gray, of Forest Hills, has described the methods by which such models may be made. (14).

14. Films

Films may be used as accessory "micro projection" with the

objective of stimulating observation, speculation and discussion among students. Many films have sequences dealing with materials which have been photographed through a microscope. A library card may be used to obliterate the title image on the screen and the teacher for instance, may make the statement—"You are going to see fertilization of the egg (or any sequences being shown). Observe carefully. You should be able to describe exactly what you have seen." If the observations and descriptions are not adequate, the film may be reversed and the sequences repeated—as many times as is necessary to insure successful learning. In this way, the film becomes an integral part of the lesson. It has been shown that students retain more of the subject matter of the film, if the film is used in this way, as opposed to the conventional method of running the film accompanying it with comment. (15).

15. Research on the High School Level

It is entirely possible for the best students to engage in actual research on small problems. Problems concerned with the culturing and maintenance of living material, natural history, and other aspects of biology are susceptible to solution by qualified youngsters. For instance, at Forest Hills, work is being undertaken on such problems as the germination of zygospores of bread mold, food preference of Chaos chaos, the culture of Spirogyra, the relationship of Dero to protozoa in micro-ponds, learning in certain invertebrates, the effect of vitamin deficiency on pill bugs, etc. The results of these investigations are acceptable, as notes in professional scientific journals. Such work—continuing throughout the student's high school career—gives those who would specialize in science ample opportunity to learn the method of science and to gain a little of the humility which comes from facing even a miniscule of the unknown. No doubt, similar work on different problems, is being done in other high schools.

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NEW STATE-BY-STATE STUDY ON SCHOOL CENSUS, COMPULSORY EDUCATION, AND CHILD LABOR

The publication of a handbook setting forth practices followed in each State relative to the school census, compulsory school attendance, and child labor, was announced today by the U. S. Office of Education, Federal Security Agency.

School Census, Compulsory Education, Child Labor—State Laws and Regulations, Bulletin 1945, No. 1, is a study of the many regulations and practices relating to child welfare services in the various States. Because these services vary significantly among the States a State-by State study was essential. The authors of the handbook are Maris M. Proffitt, Chief, Division of General Instructional Services, and David Segel, Senior Specialist in Tests and Measurements, of the U. S. Office of Education.

Complete listings are given of the State laws and regulations concerning the school census, compulsory education, and child labor, and in addition summaries of protective laws and regulations regarding children, and trends and implications of these laws and regulations are given for each of the three topics discussed. One chapter is devoted to the historical development of protective legislation for children.

Three tables, giving summaries of certain items for the school census, compulsory education, and child labor, each by State, are included.

The new publication is presented as a convenient source of information for persons concerned with the improvement of practices, the enactment of new legislation, and the administration of laws in these three phases of education and the protection of youth from exploitation in employment.

Copies of this new 200-page handbook, *School Census, Compulsory Education, Child Labor*—State Laws and Regulations, Bulletin 1945, No. 1, may be obtained by purchase at 30 cents each, from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

SIZING FOR RAYON YARNS

When synthetic rayon yarns were introduced in America, satisfactory trade acceptance depended on the development of a satisfactory sizing. Silk, which is a natural yarn, is already coated with a lubricant that minimizes friction at the weaving loom. Long experimentation finally established animal glue as the most satisfactory sizing, and today millions of pounds of glue are used for that purpose. Glue is also used as a dye levelling agent, for the preparation of water resistant or splash proof finishes and as a stiffening agent.

OHM'S LAW AND INTERNAL RESISTANCE OF CELLS

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As a rule in textbooks of physical chemistry, Ohm's law is expressed somewhat as follows: The magnitude of the electric current in a conductor is directly proportional to the difference of potential between the ends of the conductor and inversely proportional to its resistance;[1] that is

$$I = \frac{E}{R}, \tag{1}$$

where I is the current, R the resistance, and E the potential difference.

The foregoing statement gives, to say the least, an incomplete picture of Ohm's law. The student of physical chemistry ought to be told much more about it, if he is expected to make the proper use of it. What is worse, the indiscriminate use of the terms ***potential difference*** and ***electromotive force***, or emf, has come into almost general use.[2] Even many textbooks of physics are guilty of this confusion, although some of them apologize for it.[3]

Although the term electromotive force was used by Faraday himself, it cannot be regarded as a fortunate one, because the electromotive force is not really a force at all; it is a potential difference, that is, work per unit charge.[4] This must be clearly borne in mind, for when we measure an emf we measure a potential difference. But not every potential difference is an emf, and this term has therefore to be reserved only to a special case.

If we measure the potential difference at the terminals of a source of electric current (dynamo, battery or cell) when it is not doing any external work, we obtain a value which is larger than the value that we obtain when the source is doing external work, say in a resistance R.

The difference of potential of a battery when it is doing no

[1] F. H. Getman and F. Daniels, ***Outlines of Physical Chemistry*** (Wiley, ed. 7, 1941), p. 309.
[2] S. Glasstone, ***Textbook of Physical Chemistry*** (Van Nostrand, 1941), p. 874.
[3] H. H. Sheldon, ***Physics for Colleges*** (Van Nostrand, 1926), p. 298.
[4] The work done in moving unit charge through a distance dr against a potential difference dV is $F\,dr = -dV$, where F is the force on the charge. Hence $F = -dV/dr$, or the force is the negative derivative of the potential difference with respect to distance.

external work (or is compensated by Poggendorff's method) should be called the *electromotive force* or *emf*. If the battery is doing work in an external resistance the difference of potential at the terminals should be referred to as the *terminal potential difference*, or *terminal voltage*.

Ohm's law can correctly be stated in two forms. One form is

$$I=\frac{E}{R+r}, \tag{2}$$

where I is the current, R the external resistance, r the internal resistance of the source of current, and E the emf, that is, the potential difference of the source on open circuit. The other form is

$$I=\frac{V}{R}, \tag{3}$$

where V is the potential difference at the terminals when the battery is doing work in the external resistance R.

The value of V is necessarily less than that of E, because when the source is delivering current part of the work that it does is expended in its own internal resistance.[5] Equations (2) and (3) give us an easy way of determining the internal resistance of a cell. Equating the right-hand members of Eqs. (2) and (3) we obtain

$$r=\frac{R(E-V)}{V}.$$

The smaller is the value of V compared with E, the larger must be the internal resistance. Thus,for example, when a cell has an emf of 1.5 v, measured on open circuit, and a terminal potential difference of 1.4 v when it works across an external resistance of 10 ohms, its internal resistance r must be

$$r=\frac{10\times(1.5-1.4)}{1.4}=0.71 \text{ ohm}.$$

To determine r it is therefore necessary to measure the emf and the potential difference across a known external resistance.

To measure accurately the emf one must use the compensation method. Figure 1 is a simplified circuit diagram of one form of potentiometer used for this purpose. The source of current

[5] E. S. Ferry, *General Physics* (Wiley, ed. 2, 1925), p. 385.

A has an emf higher than that of B, the source whose emf is to be measured. Current from A produces a drop of potential along the wire L, of uniform resistance. When the sliding contact S is moved to such a position that the galvanometer G indicates no current, the voltmeter V shows the potential difference at the terminals of B when the cell does no work, and therefore this potential difference is the emf of B.

From Eqs. (2) and (3) it follows that $V = ER/(R+r)$. From this equation it is clear that the larger R is in comparison with r, the more closely V approaches E. For this reason, a voltmeter with a high resistance is for many practical purposes a satisfastory substitute for a potentiometer in determining the emf of a cell. However, if one applies a voltmeter to a battery working across a small external resistance R, the value of V will be very different from that of E.

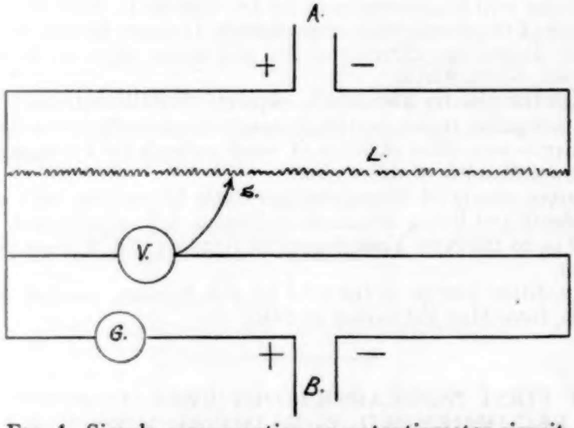

FIG. 1. Simple compensation on potentiometer circuit.

It may be worth remarking that in this country it is customary, in selling a dry cell, for instance, to test its short-circuit current, that is, simply to close the circuit through an ammeter. If the short-circuit current is large the cell is believed to be good. However, the short-circuit current depends very largely on the conductivity of the metallically conducting parts of the cell, and is in no way indicative of its efficiency in operation. On the other hand, by determining r one can see at once whether the cell is good or not, and by using different external resistances one can see within what range of resistances one can expect normal operation of the cell. Various methods which involve

the use of condensers have been proposed by Nernst and others[6] for measuring the internal resistance of cells. Apart from the fact that they require complicated apparatus, it is doubtful that these methods have any advantages over the method described.

[6] W. Nernst and E. A. Hagn, *Z. Electrochemie* 2, 493 (1896); *Z. phys. Ch.* 23, 97 (1897). W. Block, *Z. phys. Ch.* 58, 442 (1907).

EXPEDITION TO NYASALAND

An expedition to Nyasaland, South Africa, is planned by the American Museum of Natural History for next April. The museum's first large-scale expedition abroad since 1941 will be led by Arthur S. Vernay, trustee of the useum, who has sponsored numerous expeditions to remote parts of the world for the past 25 years to collect material for exhibition and research.

Southern Nyasaland is one of the few remaining parts of Africa that has not been thoroughly studied by scientists. Mount Mlanje, in the wild and nountainous country south of Lake Nyasa, is a point of especial interest. Specimens of both mammal and plant life will be collected.

Mr. Vernay will be accompanied by Dr. Harold E. Anthony, chairman and curator of the department of mammals; Leonard Brass, botanist; and Capt. Guy Shortridge, director of the Kaffrarian Museum of King William's Town, South Africa.

Although the country abounds in elephant, buffalo, antelope, lion, leopard and other game, the expedition is mainly interested in collecting shrews, mice, squirrels and other varieties of small animals for a complete picture of the mammalian life of this region.

The native plants of Nyasaland are little known, so both dried and pressed plants and living botanical specimens will be collected. This material will go to the New York Botanical Gardens, which is cooperating in the project.

The expedition will be in the field for five months, working during the dry season, from May to October of 1946.

SITE OF FIRST NON LABORATORY TEST OF ATOMIC BOMB RECOMMENDED AS NATIONAL MONUMENT

The atomic bomb explosion site in New Mexico and surrounding area is to be recommended as a national monument, the Secretary of the Interior has just decreed. In a way, the monument will be dedicated to science and to the scientists of America, Great Britain and other countries who pooled their knowledge and skills in producing the development that delivered the final stroke that hastened the Japanese surrender.

The site of the first non-laboratory test of an atomic bomb, where its destructive potency was proved, is on what is known as Alamogorda, N. M., bombing range. It is within a federal grazing district and was withdrawn for the use of the Army in 1942.

The Interior Department's recommendation that this area be made a national park must go to the President for consideration and action. Already the Commissioner of the General Land Office has received instructions to reserve the land for creation of the monument, and the National Park Service, under whose administration national monuments rest, has been ordered to make the necessary surveys as soon as the Army permits.

THE CORRELATION OF BIOLOGY AND ART

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Art as used in this article shall have reference to arts and crafts as well as fine arts. Art is synonymous with beauty in form, color, rhythm or harmony. The aim is to point out ways of correlating biology with art in a manner that will be conducive to a greater appreciation of both. The child may be made more aware of beauty in nature, in human beings, in paintings and drawings, music, and sculpture by referring to such things through biology. Such references and relationships will often awaken biological interests in some otherwise disinterested child and will more greatly extend the interests of others. One need not stop with mere association, for this manner of teaching affords wonderful opportunities for expression of both fine arts and useful or practical arts.

To those individuals who might contend that biology and art cannot and should not be linked my reply is that they are to a great extent naturally joined. That this is so is beautifully illustrated by Shakespeare through his characters Polixenes and Perdita in *The Winter's Tale*.

Act IV, Scene 3

Polixenes—'Wherefore, gentlemaiden
Do you neglect them? (Streaked
gillyvors—winter flowers)
Perdita — For I have heard it said,
There is an art which in their piedness shares
With great creating nature
Polixenes— Say there be;
Yet nature is made better by no mean,
But nature makes that mean; so o'er that art,
Which you say adds to nature, is an art
That nature makes. You see, sweet maid, we marry
A gentle scion to the wildest stock
And make conceive a bark of baser kind
By bud of nobler race: this is an art
Which does mend nature—change it rather; but
The art itself is nature.
Perdita — So it is,
Polixenes— Then make your garden rich in gillyvors
And do not call them bastards.'

The reader must keep in mind that biology is the subject being taught but that art affords media of enjoyment and expression of biological information. Many children will be interested in biology proportionally as it is made enjoyable and

useful to them. Natural objects themselves might be conceived as beautiful but they are not to be mistaken for works of art. One experiences beauty in nature and reconstructs or records this experience in a work of art. What is beautiful to one individual is not necessarily beautiful to another, and similarly, the work of art to be so considered, need not nesessarily arouse the experience of beauty in all individuals. Training can influence one's acceptance of a natural object or an art product as beautiful or ugly.

There are those rare individuals for whom the subject matter itself furnishes sufficient enjoyment and interest. They may be referred to as the pure science type. The majority of pupils, however, need to be stimulated to a greater interest in biology through appeals to their aesthetic sense. The writer has reached some by pointing out the improvement in the lines of a new model microscope over an old model. From an examination of the two they were led into use of the instrument and appreciation of the lesson at hand. On occasion when an amoeba was thought insignificant or regarded slightly, I have gone to the microscope myself and remarked for the benefit of the class as a whole, "James has an amoeba, and it is a *beauty*." Such an unusual expression in regard to the lowly organism elicited special interest. The expression, indeed, served a dual purpose. It stimulated greater interest which resulted in improved manipulation of the microscope and at the same time showed the value of appealing to the sense of beauty in the development of scientific knowledge.

With stimuli like these manipulation of the microscope now becomes pleasurable. Students work during study periods, after school, or at any time available in their search for "beautiful amoeba."

Meier,[1] in his *Art in Human Affairs*, points out that primitive man did not have a system of language communication as we know it today. He left no printed record. It is through his primitive art that we have learned much of early man. This art was largely of biological subjects such as drawings, paintings and the carving or modeling of figures of animals. Excavated refuse heaps have yielded bones of animals, shells of sea animals and the like. Man has been prone generally to undervalue art in its relation to human welfare; and this lack of appreciation comes from an inability to attain a proper perspective. The com-

[1] Norman Charles Meier, *Art in Human Affairs*.

plexity and fast tempo of modern civilization have tended to prevent an understanding of art. The teacher of biology can do much to develop appreciation.

A further extent to which biology has played an important part in the evolution of art is suggested by Meier. Primitive man noting the apparent balance in normal animals and plants developed a sort of feeling for balance. He noted that when this balance was disturbed by the loss of an appendage the organism did not function properly or was "sick." He then developed a desire for balance which has existed down to the present day.

We must not think of art as something isolated. We can have it in all fields of endeavor. Elbert Hubbard says, "Art is not a thing apart; art is just doing a thing well." Good dissections, good microscope mounts, good grafting, good artificial crossings, good models of things studied, may be considered, from this point of view, works of art for they give pleasure through their significance as well as through their beauty.

Aesthetic judgment is a desirable characteristic. According to Meier, it is the "ability to recognize aesthetic quality residing in any relationship of elements within an organization."[2] Studies[3] show that aesthetic judgment is present to some degree in children, but it is subject to considerable development through learning and experience. It is probably never completely mastered by anyone.

It is desirable in the interest of the individual's physiological, esthetic and intellectual welfare that he be exposed to and trained to recognize natural and artistic beauty and that he be given an opportunity to express his experiences of beauty.

Beauty in Nature

There is so much in nature that is beautiful if only one's eyes are opened that he may see. The teacher of biology can and should do much to point out these beauties to the child. The teacher will not see all of them, and many things which he points out to the class as beautiful will possibly never be accepted by all the pupils as being beautiful, but references to beauty will start the pupils to look for beauty and they will soon begin to find beauty for themselves. They will develop the aesthetic eye.

The teacher must be careful not to overdo teaching of the

[2] Meier, *op. cit.*, pp. 155–156.

[3] *Psychology Monograph*, 1933. Studies by Daniels, Jasper Whorley, and Waton.

aesthetic sort. There is a tendency on the part of children to rebel when this type of teaching is overdone, just as they do when too much emphasis is placed upon training in character, manners and the like.

Two or three specific lessons during the entire year of biology seem sufficient, but in addition to this the teacher must cleverly and without too much emphasis bring it in wherever an opportunity affords.

Beauty in the Laboratory

The average science laboratory is characterized by its poor arrangement of materials, lack of cleanliness and neatness, and its general absence of attractiveness. There are many science teachers who gloat over the absence of order and beauty in their laboratories. They feel that order, cleanliness and attractiveness beyond that necessary for efficient functioning of the apparatus in use involves a waste of time and energy. This may hold to some degree in a private research laboratory, but in the public school laboratories such conditions must be looked upon as deplorable. Kirby says, "There is a need for a greater emphasis upon the teacher's responsibility in the schoolroom decoration and the realization of the importance of the environment as a silent but very effective teacher."[4]

Students may, while they are learning biology, be of much help in beautifying the laboratory. Such things as cleanliness, neatness, and good taste in their surroundings are things which will serve the student as he goes through life as greatly as, or possibly greater than much of the biological knowledge he will gain.

Human Beauty

Much of the conflict between individuals and racial groups may be attributed to the fact that they look down upon others as different and all too frequently, ugly. This is true to some extent of individuals within groups and to a great extent of individuals or groups toward other groups. Just as the hatred engendered by differences between individuals and groups is largely a psychological phenomenon so can much of this hatred be dispelled through appeal to the emotions which are also psychological phenomena. But the appeal that can be made through the combination of scientific knowledge and guided emotion is more likely to obtain results.

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[4] C. Valentine Kirby, "Vitalizing the Art Curriculum for More Effective Service," *Problems in Teacher Training*, XI, p. 12.

The biology laboratory affords opportunity to help break down race prejudice by showing how scientifically unsound are concepts based upon unguided emotion and incomplete knowledge. "Africa," says Singer and Baldridge, "is usually presented as a gradiose side-show composed of freaks, Topsies, savages, burnt-cork comedians, or safari—porters and house-boys. But the traveler discovers that on the 'mysterious dark Continent,' among the 'trackless jungle' he must present passport and credentials to white police. Africa, except forlorn Liberia and proud Abyssinia, is possessed by whites. Blacks do not provide all the comedy in the tragi-comic scene."

> Consistently the grotesque has been stressed by those whose vision prejudice distorts. Photographers among these, handicapped from the start by problems of photographing black flesh with its complex reflections and by peculiarities of tropical light, have too often searched exclusively for the bizarre.
>
> We seek to convey the human beauty, the dignity and intelligence possessed by African peoples belonging to widely diversified areas and tribes; and to intimate the clash between White and Black, bewildering to both.[5]

It is highly probable that the failure of certain individuals of one race to see or admit the beauty of individuals in another race is linked up with certain moods concerning matters of sex and racial mixture most of which biology has proven to be based upon myth, prejudice and ignorance rather than fact.

Biology in Paintings and Drawings

It has been previously suggested that nature furnishes the raw materials for art. Without going into too deep a discussion of the matter, it might be said that generally two schools of thought exist concerning the relationship of nature and art.

One school holds the view that art is considered good in proportion as it closely duplicates or imitates nature. Another school holds that art is good in proportion as it tends to deviate from nature thereby permitting the artist's self to enter into it. This latter view admits the possibility, then, of illusion in good art.

Masterpieces that represent both schools have stood the test of time and are handed down to us today as great works of art.

It suffices here that in either case nature furnishes the raw materials; and that interest might be further stimulated by attempts to determine the extent to which a particular artist has distorted these materials as he uses them in his art. The

[5] Caroline Singer and Cyrus LeRoy Baldridge, *White Africans and Black*, p. 4.

better an artist views or knows his material, the more successful will he be at "distorting" it.

The reader must keep in mind that appreciation comprises both intellect and emotion, and that the degree of appreciation of a work of art by an individual is determined by the perceptions and experiences brought to it. Although mere exposure to art works may result in some degree of appreciation, informational background greatly enhances it. Even in cases of extremely modernistic works, color, line or form may offer sufficient emotional stimulus so as to result in a degree of appreciation, but if the observer is able to analyze the work or have it done for him his appreciation is placed upon a higher plane. This analysis might involve any information whatever about the work. It may be a statement of the idea that stimulated the artist, one concerning the life of the artist, the place where the work was done or how it affects certain individuals.

Trips should be made to art museums in those cities that afford them for the purpose of making a study of certain masterpieces that might have biological significance. In cities where such institutions are not accessible, reproductions might be obtained at libraries or from other sources and brought into the classroom. In cases where the pictures are too small, reflectorscopes might be used.

Biology and Sculpture

Technically, sculpture involves the chipping away of material whereas clay modeling is a constructive or building up process. However, since such an eminent artist as Lorado Taft includes both processes under the heading of sculpture, the writer shall take the liberty to do likewise. Taft suggests that:

> . . . the best way to learn to appreciate sculpture is to try to do it. It is worth the effort. You may find that you have the knack for modeling and you have opened up a whole world of joyous adventure. More likely you will promptly report that you 'can't do a thing with it,' but even then you will have learned something—how difficult it is, and much more. Understand, it is not a course in a life class which is recommended.[6]

The problem of giving the student the correct conception of the three dimensional plane can best be solved by the use of sculpture or modeling. While discussing the cell, for example, the teacher should illustrate with both drawings and clay. With a little practice the teacher can model a cell type with clay as quickly as he can draw or diagram it on the blackboard. Then

[6] Lorado Taft, *The Appreciation of Sculpture*, p. 49.

and there the class gets a better conception of the structure of cells. There are many other instances where the teacher may resort to the use of clay while illustrating biological structures.

The students should be encouraged to express themselves through any number of avialable media. A number of new plastics are now on the market. In addition to these, balsa wood, linoleum, flour and salt, clay, papier mache, soft pine, soap and plaster of Paris might be used.

It often happens that the student who is artistically inclined does not care much for science. The teacher of biology must take advantage of every opportunity to point out to such student the extent to which the student of art must know human, animal, and plant anatomy. It is not expected that the teacher of biology should know all about the teaching of art. The biology teacher, the student, and the art teacher should work together. The biology laboratory should be provided with a few sets of modeling tools, clay, and other media.

One of the major objectives of science teaching is training in careful observation. In this respect science and art are most compatible. In the words of Lester: "Clay modeling cultivates to the very highest degree the appreciation of form, size and contour. Be the study from the natural form, the cast, or original work, it demands clear and accurate observation, deft manipulation, and some exercise of taste—all important factors in educational development."[7]

When the impulse to construct is practical or results in practical objects, as do many of those done by the biology students, the application of the term *craft* is appropriate. But when the impulse becomes contemplative and the materials are handled for their own sake art arises. If we let beauty and utility be our guides, we can hardly go wrong.

Biology and Music

It often happens that students who are musical are not interested in their academic work. It has been the writer's observation, with very few exceptions, that musically inclined individuals devote so much time to their music that they have very little time for and interest in their other studies. For such students there must be an appeal in the academic subject sufficiently great to challenge their attention and interest. One

[7] Katherine M. Lester, *Clay Work*, n. 8.

of the best stimuli is the correlation of the major interest with the minor one.

When these musically inclined individuals are discovered in the writer's biology classes, he resorts to one or more of the procedures suggested below.

Have a conference with the student and point out to him the possible correlations between music and biology. Try to have him see the extent to which a knowledge of biology might be of value to him in his appreciation of music. This conference should lead to the undertaking of certain projects by the student. For example, one such student might be on the lookout for ways in which the various animals studied, hear. Have him make drawings of these hearing apparatus and finally arrange them in an evolutionary series on a large chart. He later uses this chart in explaining his project to the class. This method of procedure has often held the attention of otherwise disinterested students. They remain on the alert for any information that will contribute to their project, and so become interested in other aspects of their biology.

Another suggestion is to have a student note the sounds of various animals. Have him devise some means of illustrating these sounds in class and seeing if the members of the class can detect or name the animals he is imitating. He will work on this over a period of time in preparation for his "formal" presentation. These sounds might be discussed from the point of view of pitch, rhythm, and pleasure.

The structures used in making the various sounds and the meaning or significance of the sounds might be the object of study for another student. Of course, some of these will be discussed in the regular classroom procedure but these will be augmented by the special student.

Some student might become interested in the notes of birds and in illustrating them to the class. Many beautiful songs have been composed about birds. Some of these have been recorded, and might be played on the victrola.

Another student might be asked to make a bibliography of music having biological titles. The list will be quite long and the student might be permitted to bring a few of the more significant ones to class and play them in connection with the study of units to which they might relate.

The teacher must not hesitate to do his bit in the line of guidance. Reference might be made to individuals who earn a

livelihood on stage, screen and the radio doing imitations of birds' songs. The type of music, art and nature study coordination used in Walt Disney's "Bambi" and similar productions should also be mentioned.

A METHOD FOR DETERMINING THE THICKNESS OF SHEET MATERIAL BY FOLDING

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It is clear that for a given piece of sheet material, say a piece of paper, the number of times this material may be folded (see Fig. 1) is dependent upon its initial length L_0 and initial thickness t_0. Therefore, if the initial length and the number of times the sheet may be folded (n), as determined by trial, are given, it is very easy to obtain an approximation to the initial thickness of the material as follows:

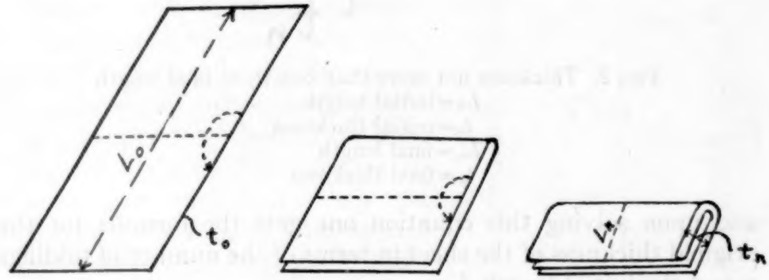

FIG. 1. Method of folding to determine thickness.

Assume that the sheet of material cannot be folded beyond the point at which its final thickness (after folding as many times as possible) t_n is one-third of its final length L_n. See Fig. 2. This assumption may be easily verified by the reader by folding a piece of paper as in Fig. 1 and measuring the final length and final thickness. One therefore has the following formula,

I. $L_n = 3t_n$ where L_n = final length, n = number of foldings, t_n = final thickness

Now since each folding halves the length of the paper, the final

length L_n will be given in terms of the number of foldings n and the initial length L_0 by the formula,

II. $$L_n=(1/2)^n L_0 \qquad L_0=\text{initial length.}$$

Furthermore, each folding doubles the initial thickness t_0 so that after n foldings the final thickness t_n is given in terms of the initial thickness t_0 by the formula,

III. $$t_n=2^n t_0.$$

Substituting II and III into I, one obtains

$$(1/2)^n L_0=3\cdot 2^n t_0$$

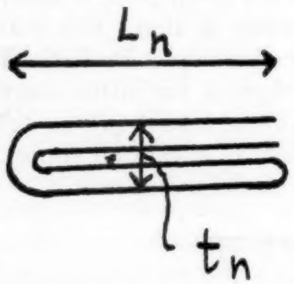

FIG. 2. Thickness not more than one-third final length
L_0 = initial length
t_0 = initial thickness
L_n = final length
t_n = final thickness

and upon solving this equation one gets the formula for the original thickness of the sheet in terms of the number of foldings n and the initial length L_0,

$$t_0=\frac{L_0}{3\cdot 2^{2n}}\,.$$

The following data illustrate the accuracy of this formula for various sheets of material.

Material	L_0	n	t_0	Micrometer t_0
Lab. weighing paper	12″	5	.0039″	.0036″
Onion skin paper	12″	6	.001″	.002″
Bond paper	12″	5	.0039″	.0036″
Tin foil	6″	4	.008″	.0068″

The above method is, of course, mainly a curiosity though it might be applied with some accuracy to very soft and thin materials which break easily when tested by a micrometer.

A GLASS NEWCOMEN'S STEAM ENGINE

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Ben Stasch of Corning (New York) has described a Newcomen's steam engine in a recent issue of School Science and Mathematics.[1] Some people are not as skilled with metal work as Mr. Stasch, in which case they might try to make one with glass and rubber.

It is sometimes well to precede the actual construction with some preliminary activities. As an introduction, boil an inch or so of water in a large test tube. Insert a solid rubber stopper which has been coated with paraffin and is of such a diameter that it can be pushed down into the test tube. Paraffin will lubricate without injuring the stopper. After the stopper is inserted let the steam condense; air pressure will drive the stopper down toward the bottom of the tube. Heat the water again and the stopper will be driven out. I have entertained both fifth and sixth grade boys with this demonstration.

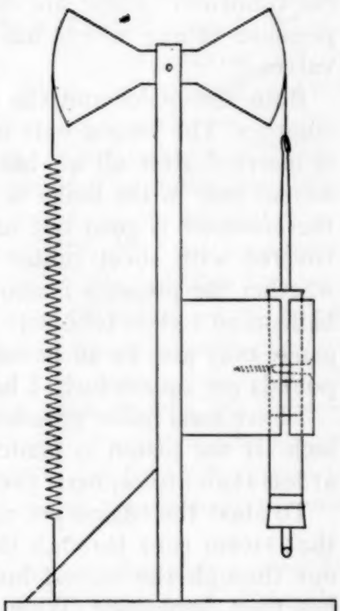

Fig. 1. A model Newcomen's pump.

It is likely that someone will want to go on with the study of this type of engine. Take out the bottom of an inch-diameter test tube, first heating it red hot and then blowing hard. Break off the bubble that forms and fire polish the edges. You now have a tube which is flared at both ends.

Make a piston and piston rod using a one-hole stopper and a glass rod or tube. Heat one end of the rod until it is soft and flatten it against a piece of wood or charcoal so that it will not pull through the stopper. Put the stopper on from the other

[1] Stasch, Benjamin H., "A Combination Newcomen's Engine and Hydraulic Elevator," School Science and Mathematics, 44: 523–526, June 1944.

end. Heat the other end and draw it small and turn a little hook on it so that a string can be tied to it.

A two-hole stopper serves as a cylinder head. Two right angle tubes are fitted into this.

The cylinder is now mounted under a walking beam. The piston rod is tied to one side of the walking beam and spring is tied to the other. The spring should be strong enough to pull the piston up and the piston must run freely enough so that it can. If the stopper is too tight trim it with a knife.

A large round-bottom flask serves as a boiler and another as the condenser. These are connected to the cylinder head with pressure tubing which has been fitted with pinch cocks for valves.

Both the boiler and the condenser are fitted with two-hole stoppers. The second hole in the condenser is for a plug which is inserted after all air has been blown out with steam. The second hole in the boiler is for some sort of pressure gauge. A thermometer is good but hard to read quickly. A thistle tube covered with sheet rubber tells by the shape of the rubber whether the pressure is above or below atmospheric. A rubber balloon on a glass tube acts on the same principle. The pressure gauge may also be an honest to goodness steam gauge reading pounds per square inch. I have used them all with satisfaction.

I have used boiler pressures as high as ten pounds per square inch. If the piston is made to run freely the engine will run at less than atmospheric pressure.

To start the engine get up steam. Open both pinch cocks so that steam runs through the cylinder into the condenser and out through the second hole in the condenser stopper which has been unplugged. When the system has been blown for a minute or so to drive out the air, plug the condenser stopper, close the pinch cock on the condenser hose, and put the condenser in a sink of water.

Appoint a fireman to watch the boiler and keep the pressure reasonably uniform. Hold both pinch cocks in the hands. The piston will be up.

Close the boiler cock and open the condenser cock. Pressure in the cylinder drops and the piston is driven down by atmospheric pressure. Close the condenser cock and open the boiler cock. The internal pressure approaches atmospheric pressure and the spring pulls up the piston. Now we can keep it going up and down and up and down and we are very happy.

MEASUREMENT OF FOREST FIRE DANGER

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Introduction

Preservation of our forests from the ravages of fire is one of the major considerations of the United States Forest Service. The work involved falls readily into three divisions. The first has to do with fire ***prevention***. A tabulation for Region 1 of the U. S. Forest Service[1] shows that the average number of fires per year for the period of 1939 to 1943 was 1724. Of these, 82% were caused by lightning, 5% by railroads, .7% by lumbering, 6% by smokers, 2.1% by debris burning, .2% by incendiaries and 2% by miscellaneous causes. Thus the man-caused fires totalled only 311 as compared to the 1413 caused by lightning.[2] By proper training of the forest users as to caution in smoking, building of campfires, burning of slash, etc., much can be done to reduce the totals from these human sources. But the large number of fires caused by lightning and the fact that unavoidable accidents will occur on the part of even the most careful of human beings makes it clear that prevention alone is not sufficient to preserve our forests from the "red demon."

The second phase of fire protection has to do with the ***discovery*** or "spotting" of fires while they are still small and can be controlled easily. This part of the program is, of course, carried on largely by the look-outs who occupy their posts during the critical months of the fire season.

Finally, comes the job of ***controlling*** the fire. This process involves a multitude of techniques and a variety of interesting tools. But it is not the purpose of this article to go into this phase of fire protection.[3]

Now it should be clear that the job of protecting any single section of forest land can be almost completely accomplished—providing that enough funds, equipment and manpower are available. Thus, if for some reason, it is urgently necessary to protect 10,000 acres of a particular forest it would be possible

[1] This region takes in the national forests of Montana, Northern Idaho and small portions of northeastern Washington and northwestern South Dakota. It includes a total of about 27,000,000 acres.

[2] The high percentage of lightning-caused fires is *not* general throughout the United States. In the eastern part of the country a greater percentage of fires are man-caused.

[3] Perhaps the most recent and spectacular development in this field has been the extensive use of parachuting fire fighters.

to station half a dozen spotters around this area, have fifty or more fire fighters on hand, large tanks of water with pumping equipment available, etc. Clearly, though, the value of the forest would have to be exceptional to justify such an expenditure. Thus, one of the problems of the fire protection man is to seek to establish some general principles to govern the amount of money that can be spent economically on any one type of fire protection. Since this is primarily a problem in economics it will not be discussed here.

Fire Danger Ratings

The phase of fire protection with which the author became most intimately acquainted during a summer spent at the Priest River Experimental Forest in Idaho, a branch of the Northern Rocky Mountain Forest and Range Experiment Station, was the job of determining a measure of ***fire danger***, i.e., of the probability that a fire will occur and spread sufficiently to do damage. This might be considered as a fourth aspect of fire protection but it is considered here as an indirect aid in each of the three branches described above. To see the need of a measurement of this kind, let us consider the problems of the fire protection man.

Now a typical ranger district in Region 1 averages about 250, 000 acres and is assigned a certain number of men and a certain amount of equipment for fighting fires. First, there are the three to eight year-long men, including the ranger and his assistants, who handle all of the regular business of the district such as timber sales, wild life, protection, recreation, etc. The number of these depends largely upon the amount of work that occurs on the district that is ***not*** connected with fire fighting. Then there are ten to twenty temporary summer fire fighters including look-outs, truck drivers, ware-house men, etc. These men are hired from May 1 to October 1 specifically for fire control work. Their number varies according to the type of year (wet or dry) and the badness of the fuel conditions in the district. As the fire danger increases, more men are added to the fire protection force and when fire actually breaks out the chief protection man seeks the open labor market (at least he did in pre-war days; now he is more likely to call upon lumbermen or some of the armed forces) for additional men.[4] Now it would be obviously highly expensive to keep the force of regular protection men and the

[4] The Kaniksu forest had 250 blue-jackets from Camp Farragut on the Bear Paw Creek fire in July 1944.

temporary men twiddling their thumbs during a fireless period and in addition there is the problem of keeping men from going "stale." On the other hand, during periods of severe fires he must be sure that he can lay his hands upon additional men. *He cannot wait until the fire escapes control by his initial force.* In days past this problem has led to some peculiar situations—sometimes amusing and sometimes tragic.[5] Thus an optimistic or reckless ranger interested in compiling a good record for low expenditure on fire protection might report a lower fire danger than a pessimistic ranger would. On the one hand then, a disastrous fire might result for want of sufficient "smoke chasers" while on the other hand a money-consuming horde of unused manpower may exist. Similar remarks apply to the *location* of the limited amount of mechanical devices available for fire fighting. In the past, moreover, even the most careful and experienced fire men might differ widely in their estimate of current fire danger. What one man might call an "easy" condition another might call a "blankety-blank bad" condition. And even if two men described the condition with the same words there was no guarantee that they meant the same thing.

Thus the need arose for some scale, free as possible from the human element, which would describe the current fire danger. It is the work of developing such a scale to which the Experiment Station has contributed so much and which is the purpose of this paper to describe, both in regard to the work already done, along with some of the techniques of physics and mathematics employed, and the possibilities of future work along this line.

Field work has established that there are six main factors contributing to fire danger. These are (1) date of year, (2) humidity, (3) wind velocity, (4) fuel moisture content, (5) visibility and (6) lightning. The first four factors are combined to give a burning index or BI which is a measure of the inflammability of forest fuels. Whatever the BI, however, if there is no source of fire *ignition*, there would still be no forest fire danger. Thus the occurrence of lightning and the visibility (which affects the spotting of fires) must be taken into account before establishing a danger class. Of course, the experienced protection man will also take into account the number (and kind!) of forest visitors, the presence of spark-producing railroads, etc. but at present these factors are not considered in the actual danger rating.

[5] See Mrs. Flint's, *The Pine Tree Shield.*

Such relatively permanent factors are considered separately for each ranger district as they are more or less constant over a period of years. Fire danger measurements, on the other hand, attempt to depict day by day variations due largely to the weather. Each of these six factors will now be discussed in turn.

The influence of the date of the year lies in the curing and seasoning of various types of vegetation and also in the length

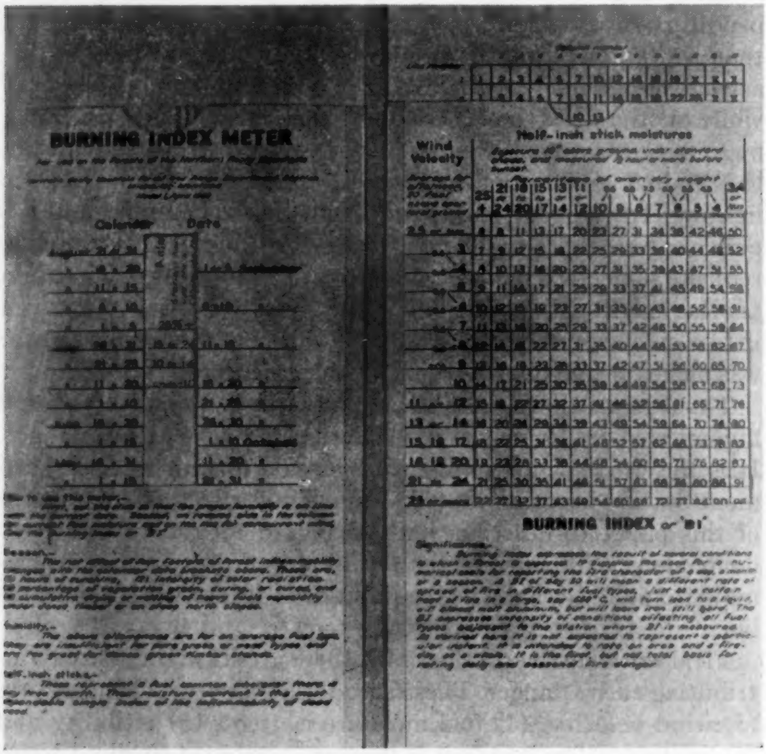


FIG. 1. The two sides of a burning index meter.

of the day. For example, the day of $16\frac{1}{2}$ hours from June 18 to June 30 means just that much longer a period of low humidity and a drying sun while a day of only $12\frac{1}{4}$ hours from September 21 to September 25 lessens the danger from these sources. This influence was perhaps the first one to be recognized as a factor in fuel inflammability. For Region 1 the vegetative fire season is considered to begin about May 1, usually reaches its peak in the period from August 21 to 31 (unless modified by heavy rainfall

or high humidity) and then declines, somewhat more rapidly than it ascended, to end about November 1. Next to be recognized as a factor was wind which plays a major role in the *spread* of fires. Then humidity and fuel moisture came to be considered. These factors are related in that humidity is actually an index of the moisture content of *fine* fuels. It was not until comparatively recently that the need for a separate index for coarser fuels was recognized.

Now in a fashion similar to that employed by Birkhoff in aesthetic measurement[6] these factors are combined to yield a BI number ranging from 1 to 100. To simplify matters for the field men a sort of slide-rule affair (see figure 1) has been constructed which enables the BI to be calculated in a few seconds. As examples of the use of this calculator suppose that the date of the year is July 27, the lowest humidity of the day is 22%, wind velocity (average for the afternoon) is 5 mph and fuel moisture content (determined as described in the next section) is 7%. Then the BI would be 41. Now suppose that it is August 22, the humidity is 12%, wind velocity is 6 mph and the fuel moisture content is 5%. Then the burning index would be 70. With the wind in the second example changed to 18 mph the BI would be 100—the maximum.

To obtain the danger class or DC one now rounds off the BI determined as above to the nearest multiple of 5 and applies another slide-rule affair to take into account the effect of low visibility and the occurrence of lightning. The lower the visibility and the more recent the occurrence of lightning the higher will be the resulting DC which likewise runs between 1 and 100.

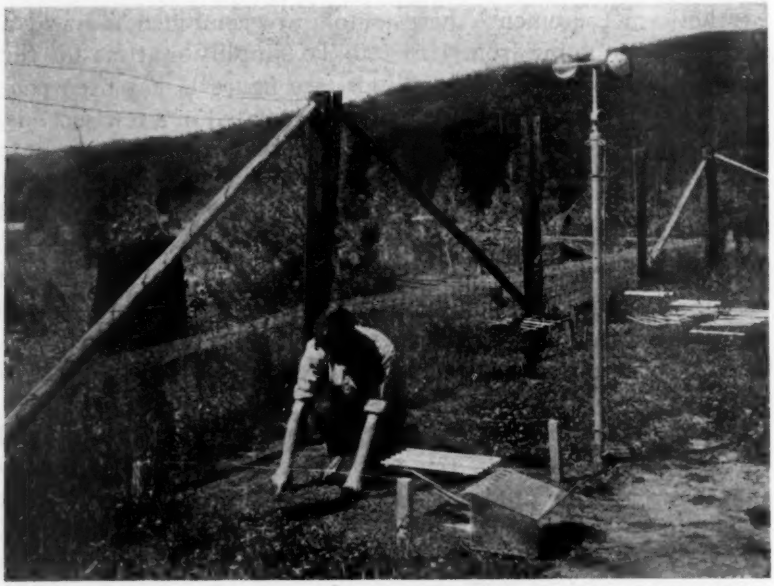
Instruments and Procedures

The humidity desired for computation of the BI is the lowest humidity of the day. For stations equipped with a hygrothermograph this is a simple request. Most stations, however, are not so equipped and use the measurement of humidity taken with a fan or sling psychrometer late in the afternoon.

Various methods are used for the measurement of average wind velocity in the afternoon. They are all based fundamentally on readings from a standard 3 or 4 cup anemometer 20 feet above the ground. This uniformity of height, making readings from different areas immediately comparable, is in sharp contrast to the practice of the United States Weather Bureau which

[6] See for example the article of the author listed in the bibliography.

has its anemometers placed at variable heights. As a result, the average wind velocity for New York City is given by the Weather Bureau as 14.0 miles per hour while that of Chicago is listed as only 10.3 miles per hour. But, the anemometer in New York City is at a height of 454 feet while the one in Chicago is at a height of 131 feet! Further discussion of anemometer readings will be made in the next section in connection with a description of inaccuracies of measurement.



Photograph courtesy U. S. Forest Service

FIG. 2. View of "Full-sun" station on the Priest River Experimental Forest. In the foreground is a set of standard sticks coupled to an automatic weight recording device.

Fuel moisture is obtained from the weight of calibrated $\frac{1}{2}$ inch sticks whose oven dry weight has been accurately determined. To insure uniformity in conditions of measurement, all sticks are exposed under two thicknesses of 11 mesh wire screen in a clearing (see figure 2).

Visibility is reported by a look-out near the point at which the other observations are taken. He gives the distance at which atmospheric transparency permits dark ridges to be seen or uses a visibility meter.[7] The final figure that he reports is actually an

[7] Developed by G. D. Shallenberger and E. H. Little of Montana State University in cooperation with the Northern Rocky Mountain Range and Forest Experiment Station. See bibliography.

average of sixteen readings taken at four different times during the day in each of four different directions.

Finally, it may be mentioned that danger classes reported by phone or forest service radio from various stations are averaged in different ways so as to obtain a representative figure for a ranger district and another way to obtain a figure for the forest as a whole.

Future Work

Much work needs to be done in developing cheap but accurate instruments for meteorological observations of various kinds. An automatic wind recorder cheap enough to permit installation at every station would be of considerable assistance. Present practice in wind velocity determination is to take three two-minute observations at 1 p.m., 3 p.m. and 5 p.m. and average these to obtain the average wind velocity for the afternoon. Clearly there is a possibility of serious error in this procedure.[8] Also the night winds usually escape observation entirely. The Northern Rocky Mountain Range and Experiment Station has designed a cheap 4 cup anemometer costing only $10 in comparison with the $85 for a standard Weather Bureau 3 or 4 cup anemometer for use in many places where only current velocities are needed. The Forest Service also has a rain-gage which gives satisfactorily accurate results,[9] and costs only $1.50 in comparison with the Weather Bureau rain-gage which costs $11. The Pacific Northwest Experiment Station has designed a handy fan psychrometer which nevertheless the author believes could be improved in several respects. Very useful would be a fairly sensitive and accurate hygrometer of the type usually made for home use. Many other possibilities will undoubtedly occur to the reader who is familiar with physical and meteorological equipment.[10]

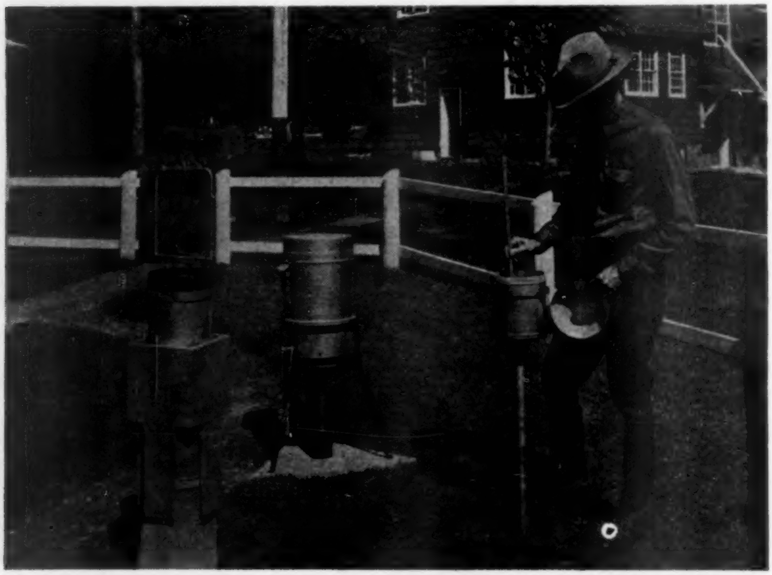
As an integral part of the fire protection plan weather forecasts are sent out every morning (or oftener in critical periods) by the U. S. Weather Bureau. These forecasts are often based on a considerable amount of local data and are sometimes localized to cover only a single forest or even, in extreme cases, a single fire. However, the difficulties in giving very local forecasts with-

[8] See William G. Morris, "Comparison of 1-, 2-, 4-, 6-, and 8-minute Wind Velocity Measurements," *Fire Control Notes*, 1942, 6, pp. 25–27.

[9] See G. L. Hayes, "Reliability of the Forest Service Type Rain-gage," *Monthly Weather Review*, 1942, 70, pp. 267–268.

[10] It is encouraging to note in this respect that several companies currently engaged in war production have inquired about the possibility of making apparatus of this type.

out collecting an enormous amount of data are obviously considerable. So another possible topic for research would have to do with the development of some "easy" methods of spot forecasting. As a sample of the type of theory which is useful we may consider the fact that[11] if the minimum temperature during the night at the top of a mountain is lower than the minimum temperature at its base,[12] a local thunderstorm or high winds in that area may be expected the following day in 9 cases out of 10. The reason for this is fairly obvious. The rising warm air from the



Photograph courtesy U. S. Forest Service

FIG. 3. The gage being used is the Forest Service type. The standard weather bureau gage is at the left while the center gage is an automatic recording type.

base of the mountain comes into contact with the cold air at the top and a local disturbance is created.

A study to which considerable time was given at the Priest River Station a few years back was the influence of altitude and aspect on fire danger. For details of this study the reader is re-

[11] See H. T. Gisborne, "Paired Minimum Temperatures as Indices of Fair or Foul Weather," *Applied Forestry Notes*, 1934, Number 65.

[12] The lower temperature at the mountain peak (if the peak is of moderate height—say from 1,000 to 10,000 feet) is not common. It is cooler in the daytime at higher altitudes but, in general, warmer at night—contrary to popular belief. This phenomenon is known as ***temperature inversion***.

ferred to Hayes' paper listed in the bibliography. Further work is needed on this question and is one of the post-war projects planned for the Priest River Station.

Current study is being made of the influence of a winter's precipitation on the following summer's fire danger. As yet no definite conclusions have been reached but it appears as if an index of this may be the date at which the per cent moisture content of 6 inch logs falls below the per cent moisture content of 12 inch logs.

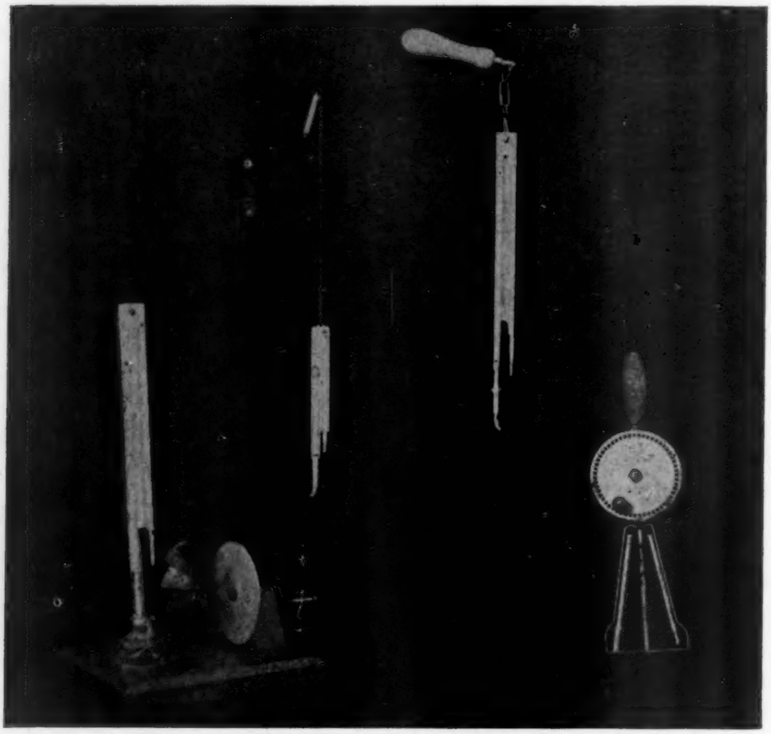
Another current fire research project has to do with determining the date at which grasses and other vegetation may be considered to be completely cured as it is at this time that the danger is greatest from grass fires. Various possibilities are being considered. One is the date at which the relative humidity at the grass root level becomes lower than the relative humidity at the 5 foot level. Another is the date at which a certain percentage of the blossoms of the yarrow plant turn brown. Even the date at which the Columbian ground squirrel "holes up" may be a possible indicator!

Finally we might mention the various uses of mathematics in this field. There is need, of course, of the various tests of correlation, error and reliability in many aspects of fire danger measurement. One study that the author undertook was an analysis of the possibility of using wind movement at 150 feet (recorded automatically at the station) to obtain the average wind velocity about a half mile away at a height of 20 feet. The conversion chart used for this purpose was found to be in error largely because the data used in its construction were obtained in a rather inaccurate fashion and this inaccuracy added to the fact that there was not a perfect correlation between the winds at these two places threw the results beyond the limits of tolerance. By proper experimental technique and statistical analysis it was possible to replace this chart by one which gave the wind velocity to within one mile per hour in nine cases out of ten.

A problem of great importance is concerned with *sampling* technique. For example, in attempting to evaluate the climatic conditions of a vast uninhabited region of forest land how many meteorological stations must be constructed and where? Data is gradually being accumulated which some day, in the hands of an expert statistician, may answer this question.

Perhaps the most difficult problem at hand is the question of the proper technique to use in obtaining the BI or DC from a

knowledge of the various factors. Obviously the problem cannot be handled by elementary mathematical techniques but there may be some more advanced techniques which might apply. For example, the method now used is similar to that which Birkhoff used to measure aesthetic value and might be refined further to yield better results. Another possible approach is the factor



Photograph courtesy U. S. Forest Service

FIG. 4. From left to right we have the fan psychrometer, pocket sling psychrometer, standard sling pyschrometer and egg beater psychrometer.

analysis of Dr. Thurstone of the University of Chicago. This method has been used for the analysis of various factors of intelligence. In all cases, though, it must be borne in mind that any scheme adopted must be usable in the field by men who have not had special training in mathematics and physics.

To sum up: From the author's brief experience in the field of fire protection (and forestry in general) he believes that there is a real need for foresters with a considerable background of phys-

ics, chemistry and mathematics. The so-called forestry mathematics taught at many forestry schools (including that at the author's own University) is just the ***minimum*** required for handling almost any kind of forest research today.

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INDUSTRIAL RESEARCH FOR INDIA

Nine specialized laboratories for industrial and scientific research are recommended for India, to be erected during the next five years, by an Indian Industrial Research Planning Committee, it is just revealed by the information service of the Government of India. A technological institute on the lines of the Massachusetts Institute of Technology is included in the recommended program for scientific development, and also a $6,000,000 grant to the scientific departments of India's 18 universities to be used in training 700 research workers in the next five years.

The Industrial Research Planning Committee was appointed in 1944 by the Government of India's Council of Scientific and Industrial Research to make a comprehensive survey of existing facilities for scientific and industrial research and to report on necessary measures of development, coordination and control of various research agencies in India.

Members of the committee visited the United States in 1944, inspected American research undertakings and consulted with American scientists.

The Indian committee recommends for control a National Research Council, consisting of representatives of scientific bodies, universities, industry, labor and administration. The council, in addition to its duties in maintaining national research activities and stimulating research by private organizations, would also serve as a national trust for patents and set up a board of standards and specifications.

SOME FACTORS INFLUENCING SUCCESS OF CAMP NATURE PROGRAM

Opinions of Camp Directors

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The camp nature program is one of the most difficult problems with almost every camp director and with others interested in advancing the knowledge of our natural environment. The summer camp program and location seem to offer unlimited opportunities for transmitting to the younger generation a real knowledge of their natural environment, yet only too frequently the campers are bored by the type of program presented, and learn little or nothing. It goes without saying that this is not invariably the case, but camp directors and nature leaders deplore the frequency of such failures. The reasons for the failures are not always easy to find. Unquestionably it is not to be looked for in the equipment and surroundings, for there is not a summer camp in the United States that is not surrounded by a wealth of natural history materials. Little equipment is needed to teach woody plants, herbaceous plants, snakes, salamanders, insects, rocks, minerals, stars, waterlife, etc., when all these objects literally beg to be seen and understood. The lack of equipment argument which is sometimes heard is probably based on classroom methods having been carried over to the camp situation.

It may be that the limiting of the nature program to an activity period of from one to two hours per day is responsible for the lack of interest in natural history. Certainly the definite time and place arrangement leans toward the classroom techniques which have little place in a summer camp. The author feels that the nature program should cut across all activities, and that the nature counselor should be employed at all hours interpreting the natural history of the various activities of the camp. In addition all counselors should have a sufficient knowledge of natural history to give something of value even though this is not their specialty. This seems extreme until one recalls that the purpose of camping is to give young people an opportunity to get close to nature under the supervision of skilled interpreters. Too many music, dramatic, art, swimming, and athletic counselors miss the point of camping by ignoring their

function as woodsmen and naturalists and confining their attention to their specialties.

Be that as it may, in the final analysis the program can be no better than its leaders. The nature counselor must be able to sense the difficulties and make the necessary changes to meet them. If the program does not attract campers, the nature counselor should devise a program that will. Few would agree that the subject is so dull as to be without interest to the youthful camper.

There has been all too little planned education for the nature counselor. Few schools offer training of this type. Studies have

Number of questionnaires returned........................ 102

Factors influencing the success of the nature counselor	Number of times checked as being of *great importance*	Number of times checked as being of *some importance*	Number of times checked as being of *little importance*
How to interest children	80	4	1
Enthusiasm for subject	78	3	1
Personal conduct in camp	70	8	1
Knowledge of children's interests	62	9	3
Bird hikes	60	25	2
Knowledge of subject	58	12	1
Emphasis on practical nature	57	19	2
Building nature trails	52	23	6
Experience in camping	48	24	7
Improvising equipment	46	27	6
Freedom from classroom methods	46	18	6
Leading overnight trips	46	31	9
Building camp museums	46	30	7
General campcraft	46	29	7
Suitable nature literature	40	39	2
Swimming ability	37	25	18
Nature games	35	29	17
Constructing nature gardens	35	32	13
Plant and animal photography	34	42	18
Emphasis on aesthetic nature	34	28	10
Making plant collections	33	42	7
Care and handling of animals	28	37	13
First aid	28	43	12
Making animal collections	25	39	15
Boating skills	20	32	24
Ability to conduct athletics	18	18	38
Making plaster models	12	28	33
Direct subjects other than nature	10	23	21
Scout training	9	37	25
Fishing skill	8	28	34

shown that increased schooling of the conventional courses does not always result in superior nature counselors. Usually the schooling is not directed toward camp work, but toward teaching in public schools, agricultural work, specialized botanical or zoological fields, or research. Such preparation, while rich in content, does not adequately prepare students to teach natural history in the summer camp.

It was with these thoughts in mind that the following study was made in order to find a basis for organizing a course to prepare nature counselors. The plan was to determine by means of a questionnaire, what camp directors thought were the important factors influencing the success of the nature counselor. It was thought that camp directors would be in a very favorable position to know these factors. At least they are in a position to know whether or not the campers became interested in the program offered by the nature counselor.

Accordingly a questionnaire was sent to the camp directors. The results of the questionnaire are tabulated above.

There is little need to interpret the results of this questionnaire. They should be of exceptional value to those interested in camp work for the summer, and to those training prospective nature counselors. Additional remarks on the cards returned usually stressed the importance of the personality of the naturalist. It is essential that he be a "regular fellow" who can mingle easily with the campers, guests, and co-workers at the camp, and really enjoys such associations.

SANDPAPER A RECENT PRODUCT

Sandpaper is a comparatively recent product of civilization. The first abrasive in sheet form was shark skin originally used in the 12th century. The Chinese, a hundred years later, attached powdered sea shells to parchment with natural gums to make a crude sandpaper. Later the Swiss used ground glass coated to a hide for wood finishing. Sand and glass were glued to paper on a commercial scale in England about 350 years ago and in 1825, the first sandpaper factory was established in this country, making glass coated sandpaper. Abrasive grains used today are not sand but crystolan (silicon carbide), alundum (aluminum oxide), Garalum (aluminum oxide), and others. All of these synthetic abrasives are products of the electric furnace and in hardness approach that of the diamond. With garnet,flint, and emery carefully sorted for grain sizes, and firmly anchored to paper, cloth, and fibre backing with animal glue, they come to the market in the form of belts, discs, and special shapes.

MASTERY OF THE FUNDAMENTALS OF HIGH SCHOOL MATHEMATICS: A GRADUATION REQUIREMENT

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Civilization and Mathematics Supplement Each Other

In the history of mathematics these facts stand out clearly: mathematics grew out of the needs of man; civilization and mathematics developed together; and at all stages of civilization the available knowledge of mathematics has aided its progress. Indeed, there have been times when civilization could not advance and stopped temporarily waiting for further development of mathematics. Today, mathematics fills a greater need than ever. It is still making contributions to civilization.

Even before primitive people were able to count the number concept had its beginning in their minds. When man needed to enumerate possessions, things and persons, counting developed. In the absence of number symbols it was natural that people at first counted by using fingers and toes, but they also used shells, pebbles and other objects that were conveniently available. They kept records of possessions of individuals and tribes by cutting notches into trees and sticks, very much as we keep score today by drawing short lines next to each other.

The time came when with the advance of civilization different peoples invented number symbols and created number systems. Our own number system has been traced back to the ancient Hindus and Arabs. Its later acceptance throughout the civilized world it owes to the fact that it lent itself better than any other system to numerical manipulations, need for which grew out of the development of trade and commerce. Slowly the scholars of Europe improved methods of computation thereby making possible the world's advances in astronomy, navigation, science and surveying.

With the growth of business and commerce on a large scale business arithmetic developed. The loaning of money led to the custom of paying interest at specified rates. The losses of ships and cargoes caused by storms or by war created the demand for insurance. Thus, out of man's need has developed the subject of arithmetic as it is being taught in the schools of today.

Algebra developed from the effort of improving ways of solving problems. Several thousand years ago the Egyptian priests are known to have labored with problems in a clumsy way by using number words where today we use numerals, and sentences when we now employ algebraic equations. A great advance was made when mathematicians invented a single symbol to denote an unknown number. The next step was to introduce a letter as a number symbol. However, several hundred years passed before the idea of using letters to denote numbers actually took hold.

Modern algebra really did not begin before the later part of the sixteenth century. It does not replace arithmetic, but it makes use of all the knowledge of arithmetic and adds to it such concepts as literal numbers, positive and negative numbers, exponents, formulas, equations and graphs. It has tremendous advantages over arithmetic because it expresses facts about numbers and number relationships more compactly and clearly than is possible with the long verbal statements of rules used in arithmetic. Moreover, in algebraic form number facts are readily grasped, retained, and communicated to others. That is the reason why scientists do not rest until they are able to state algebraically the laws of science expressing quantitative relationships.

Man early had a desire to make his surroundings pleasing to the eye. Evidence of this is available in the crude decorative designs which have been found on the ancient monuments of Mexico, India, China, and Egypt and which consist merely of some simple roughly drawn lines. This was the beginning of geometry. In time the lines were drawn with more care. Parallel lines, triangles, quadrilaterals, circles and other geometric figures were created and used for the purpose of ornamentation on clothing, draperies, rugs and pottery. Step by step Egyptian, Greek, and other civilizations progressed to more and more advanced forms of ornamentation. Geometric figures are found on the porcelain of the Chinese, the Byzantine mosaics, the Gothic cathedrals and the paintings of the Renaissance. Primitive people erected the huts they lived in with a vague knowledge of triangles and of several other simple figures. They told the time of the day by watching the lengths and positions of shadows of trees. They did not need surveyors and engineers to erect bridges. They did not cross the seas.

The time came when civilization could not advance until

people had acquired greater knowledge of geometry. The Egyptians needed it to design their pyramids and temples before they could build them. They constructed extensive projects of irrigation. After the annual floods of the Nile the farmers had to have their land surveyed to reestablish ownership. Through all these activities they discovered a wealth of geometric information which they then applied in a practical way. Thus to facilitate the measurement of grain and produce they learned how to determine areas and volumes.

The Greek mathematician Thales used geometry to find the distances of ships from the shore, and to determine the heights of the pyramids by using the lengths of the shadows. Archimedes discovered the law of levers and used a lever device for launching ships. It is said that his knowledge of conic sections led him to discover the "burning glass" by means of which he could focus the sun's rays on enemy ships in the harbor to set them on fire. Kepler discovered that the paths of the planets in the solar system are ellipses with the sun at one focus.

The Greeks developed a new phase of geometry by disregarding the practical uses. While the Egyptians established geometric principles in a practical way by observation, measurement and comparison, the Greeks derived them by the processes of reasoning and abstraction. Then they arranged all the known facts in a logical sequence of theorems and problems to form a "system" of geometry. This type of geometry is called "logical" geometry.

Trigonometry, like algebra and geometry, developed in response to mathematical needs that arose in the studies carried on by ancient mathematicians. The basic notions date back to the Babylonians, Egyptians, Hindus and Arabs. Their ideas were developed further by the Greeks as an aid to the study of astronomy. Trigonometry continued to grow and improve through the centuries. It is a combination of arithmetic, algebra, and geometry, and the elementary notions are as simple as those of algebra and geometry. Trigonometry is a valuable instrument in surveying, engineering, aviation, navigation, astronomy, geology, geography and physics.

The Value of a Mathematical Education

While mathematics grew out of the needs of man it has long ago ceased to be the need of only a small group of users. Thus, today everybody needs arithmetic.

Modern industry, business and science are thoroughly dependent on arithmetic.

Governmental agencies deal with all kinds of arithmetical problems relating to expenditures, taxes, agricultural output, industrial production, manpower, unemployment, crime, relief and price regulation. All of these matters are of concern to the citizen. To understand and appreciate discussions relating to them he needs a good arithmetical background.

People in all professions encounter numerical situations. Knowledge of arithmetic is needed by farmers, miners, mill employees, truck drivers, waiters, salesmen, insurance agents, and all those engaged in an endless number of other occupations. Even unskilled workers run into jobs requiring ability to compute with whole numbers and fractions.

Number also enters into most phases of home life. Quantitative problems arise in dealing with budgets, bills, accounts, purchases, travels, parcel post, installment buying, saving, borrowing, investments, pensions, insurance, annuities and income taxes. This list, by no means complete, is sufficient to show that our everyday life is filled with quantitative ideas and problems involving computations which require proficiency in arithmetic and which cannot conveniently be turned over to experts, or performed by computing machines.

The value of arithmetic in the war effort has been emphasized by the military authorities. They pointed to the importance of arithmetic to the military needs and in the technical training of men and women. Indeed the schools received rather severe criticism because an unduly large percentage of high school graduates was poorly grounded in arithmetic. These deficiencies raised some serious questions in enrolling men at the training stations. Too many could not be admitted until they were able to show that they had attained the required arithmetical skills. Accuracy and speed in computation are essential to all men and women in the service, and familiarity with the arithmetical processes is the minimum mathematical preparation expected of the private. All pre-induction courses place emphasis on proficiency in arithmetic.

A knowledge of algebra is today essential to an increasingly large number of people. In the industries it is needed in carrying on scientific investigations. In the war effort men trained in research use it in designing and building battleships, tanks, jeeps, flying fortresses, anti aircraft guns and howitzers. The men who

take them over and operate them also make use of algebra. They must know and apply the laws and principles of mechanics, electricity and radio. They must understand relationships when they are expressed in formulas and equations. Thus, the pilot who plans the flight uses algebra in the performance of his many duties. He directs the course of his ship, determines the proper speed and altitudes and computes the amount of fuel necessary for the trip. All preinduction outlines of the Army and Navy designate high school algebra as an essential requirement.

In numerous occupations in which young people expect to engage as adults the use of algebra is on the increase, and since so many women have demonstrated that they are able to do much of the work formerly done by men algebra has become as important for girls as it is for boys.

Intelligent study of such subjects as chemistry, biology, economics and geology requires a knowledge of algebra. Anyone who attempts to study physics without it can at best only gather information about the laws and principles of physics but will fail to attain a real understanding, which after all is the essence of that subject.

Because the verbal statements of rules in arithmetic are difficult to retain, many people run into confusion when they use them in solving problems. For example, in solving a percentage problem they have to select one of the three rules of percentage depending on whether they are to find the percentage, rate or base. Then they have difficulty in selecting the correct process leading to the solution, that is, in deciding whether to multiply or divide. If they choose division the question arises: which number is to be divided by the other? When the problem is finally solved they are not sure that the right thing has been done. So they must employ some kind of check to reassure themselves.

Compare this procedure with that of a person trained in algebra. He works with speed and assurance. He solves all percentage problems with one formula: $p=rb$. No matter which of the three numbers is to be found a glance at the formula leaves no doubt in his mind as to which process is to be used.

Algebra is a valuable language. The statement: "Interest on a sum of money to be paid at the rate of four per cent is found by multiplying the rate of interest by the amount invested," when translated into algebra takes the simple form $i=.04\ p$. Much would be gained if all citizens could be depended on to have some familiarity with this language. Thus, instead of telling the appli-

cant for an automobile license in the state of Illinois: "To determine the horse power of your car square the bore and multiply the result by .4 of the number of cylinders" he could be told simply to use the formula h.p. $=.4\, n\, d^2$.

Algebra is a powerful instrument in the hands of those who are investigating problems. Before Galileo's time it was well known that an object when dropped from a cliff increases its speed as it passes through the air, but scientists had yet to find an exact way of expressing the relationship between time, distances and speed of the object. Galileo observed that there existed a uniform law according to which all falling bodies, large or small, move at the same rate if the resistance offered by air is disregarded. But when Newton expressed the relationship between time and distance, known as the "law of falling bodies," by the simple formula $x = \frac{1}{2} gt^2$, the law was in a form in which it is easily understood by anyone. It can be applied readily to find the distance passed over by a falling object in a given time. Moreover, it gives a description of the nature of the motion. It shows the change that takes place in distance corresponding to the change in time; that the motion is accelerated; that in two seconds the distance passed over is four times that of the first second; in three seconds it is nine times that distance; in four seconds it is sixteen times that distance; etc.

In modern life very large numbers have come into wide use. Election returns, populations, sizes of countries, crop yields, distances to foreign shores and government expenditures run into thousands, millions, billions and trillions. Newspapers and magazines are filled with discussions relating to these matters. Unless the reader understands large numbers and knows how to manipulate them he fails to derive any clear thought when he sees them on the printed page.

Of the various ways of helping people understand the meaning of large numbers, none is as simple as the algebraic way. By the use of exponents, one hundred, being equal to 10×10 is written briefly 10^2 (read 10-square). One thousand, being $10\times 10\times 10$ is abbreviated to 10^3 (read 10-cube). Similarly, one million $=10^6$ and one billion $=10^9$. The exponents 2, 3, 6 and 9 make it as easy to understand a million and a billion as it is to understand 6 and 9. However, the real advantage derived from the use of exponents lies in the facility with which one may operate with large numbers. For example, let us determine the number of miles per day which we travel on our journey around the sun. We know that the average distance, d, of the earth from the sun

is 92,900,000 miles. An algebraic formula gives the required distance $D=6.28\times d/360$, where $d=92{,}900{,}000$, which may be abbreviated to 92.9×10^6. The required number of miles is therefore $6.28\times 92.9\times 10^6/360$. This reduces to 1.6×10^6 which is approximately 1.6 times a million miles per day.

Another common example of the use of exponents in working with large numbers is that of finding the number of miles from the earth to a star. This is an exceedingly large distance and astronomers express it in terms of a unit ever so much larger than a mile. They use the distance traveled by light in one year. This is no small number when we consider the fact that light travels at the rate of 186,000 miles per second and that a year contains $360\times 24\times 60\times 60$ seconds. The distance traveled by light in one year is therefore $186{,}000\times 360\times 24\times 60\times 60$ miles. By introducing exponents this may be written $186\times 36\times 24\times 6\times 6\times 10.^6$ The star nearest to us, Alpha Centauri, is 4.27 light years away. Hence the required distance is $4.27\times 186\times 36\times 24\times 6\times 6\times 10^6$, or 247×10^{11}.

The answer is now in a form which makes further manipulations easy, as for example, if we wish to compare the distance of Alpha Centauri with that of other stars farther away.

Exponents are just as helpful in calculating with very small numbers. The scientist measuring the wave length of light uses as a unit of measure an exceedingly small length which equal to the ten millionth part of a millimeter or 1/10,000,000 millimeter. When expressed in exponental notation this unit takes the simple form $1/10^7$ millimeter. The diameter of a red blood corpuscle is $75/10^4$ millimeter. The width of an atom is less than $1/10^9$ millimeter, that of an electron $1/10^{14}$ mm; and that of a proton $1/10^{17}$ mm. in the exponential form such measures offer no greater difficulty in calculating than those of objects which are large enough to be seen with the naked eye and which can be measured with yardstick or tape line.

Forty years ago only the college student had the opportunity of learning about graphs. Since that time they have been moved downward and today they are presented, in simplified form, in high school algebra. In the high school, graphs are used in a number of school subjects. They are of importance to all those who prepare for the study of the sciences and more advanced mathematics.

In business and industry the trend is toward an increase in

the use of graphic ways of expressing numerical facts and relationships. Graphs even more than formulas and equations, have made a place for themselves in newspapers and periodicals. The trend will continue as more and more people understand algebra.

Graphs are used to clarify the meanings of statistical facts relating to national expenditures, taxes, exports, imports, populations, areas and distances of foreign countries, agricultural output, industrial production, stock fluctuation, losses in war, manpower, and an almost endless number of other matters of importance and interest to the reader. Graphs have become very popular because they arouse curiosity, save the reader's time, and require comparatively little mental effort while at the same time they increase the power of retention. Graphs visualize quantitative facts, clarify relationships and disclose trends.

One of the great values of the study of algebra lies in the training it offers to solve problems.

The ancient Egyptian priests had no definite technique of problem solving. Using a kind of trial and error method they made a guess of an approximate answer and then tried it out to see if it satisfied the problem. If it did not, they corrected the error and tried out the new answer. This was kept up until a satisfactory result was attained. As a rule, this process of solving problems is tedious. Anyone who has acquired a definite technique of problem solving has an immense advantage over those who manipulate aimlessly the numbers of the problem hoping to "hit upon" the answer. Yet this is the only way of solving problems some people seem to know.

A test was administered to a group of adults to determine the mental process which they used in solving problems. One of the problems was to find the yield of a stock selling at $42 and paying a dividend of $2. Each person had been instructed to describe the mental process by which he obtained the answer. A typical procedure of an untrained person follows.

"I know I must divide. Multiplying would give the stock dividend."

"I might divide 42 by 2. Clearly this cannot be right. So I divide 2 by 42."

"The yield is $4\frac{3}{4}$ per cent."

"I made sure that the answer is right by multiplying $4\frac{3}{4}$ per cent by 42."

The procedure is tedious. Throughout the solution the lack of assurance is apparent. Confidence in the correctness of the result

does not come from confidence in the process. After each step some kind of check seems to be necessary.

A person who has not learned the algebraic technique experiences a feeling of inadequacy when confronted by a difficult problem, while one who has algebraic training approaches the solution with confidence and pleasure. He knows that as soon as he succeeds in changing the problem into algebraic form he can be certain of a correct solution.

Geometric designs and ornaments are in evidence on buildings, furniture, floor coverings, tapestry, quilts, dishes, jewelry, in fact everywhere.

Geometry is an aid to the artists who create the designs and to those who wish to enjoy them. It helps man satisfy his craving for making things beautiful. It develops his appreciation of the beauty of geometric forms observed in nature, such as the symmetry of the snow flake, the honeycomb of the bee, the web of the spider and the arc of the rainbow.

However, this is not the only reason why the properties of geometric figures are taught in the schools. People use a large amount of geometry in practical work. Contractors, carpenters, masons, plumbers, and electricians need geometry to make and read the drawings and blueprints of floor plans and buildings.

The engineer uses geometry in planning bridges, tunnels, and dams; the architect in designing buildings. The imposing structures which he erects are indeed monuments to his skill, and to his knowledge of geometry with which he creates curved arches, conical and pyramidal church towers, cylindrical columns and prismatic pillars.

Without a knowledge of geometry we can not understand our own solar system and the movements of the moon, earth, and other planets. The changes of the seasons, the phases of the moon and the causes of an eclipse will always remain a mystery.

Every person meets an abundance of experiences in which geometry is needed. Often he makes use of information gathered in school or elsewhere, applying it subconsciously. The man who nails a board to the opposite corners of a gate to keep it from sagging, whether he knows it or not, draws upon useful and valuable information previously acquired. He employs the same geometric principle as the engineer who designs bridges, derricks, and airplanes made rigid by means of the triangle or a network of triangles.

Yet, it is surprising how many people are totally unaware of the simplest geometric facts in their surroundings. They do not know the width of the street in front of the home and the height of the home they live in. They are uncertain as to the length of a foot or a yard. They have never noticed the decorative designs on the buildings they pass every day, or the prismatic, cylindrical, pyramidal and spherical forms of the imposing downtown structures of their city.

The homemaker uses a great deal of geometry. By measurement she secures the data to determine sizes of rugs, tables, dressers, closets and rooms. Screens, shades and storm doors have to be measured to compute costs before ordering. Lengths and widths of shelves for closets and pantry have to be obtained before they can be installed. It is not sufficient that the housewife making purchases at the store is careful as to quality of the goods she buys. It is just as important that the quantity is the largest for the money she spends. Olives, pickles, honey, peanut butter and numerous other articles are put up in containers of various sizes and shapes. To the untrained observer the smaller container sometimes appears to hold the greater amount. The purchaser must know geometry to determine the correct content. Her decision depends on her ability to judge shapes and to estimate or compute sizes.

Knowledge of geometry is essential in various high school subjects. It takes skill with the geometric instruments to make good drawings and graphs. The maps in geography are scale drawings. Space imagination is required to visualize lengths of rivers and sizes of countries. To understand latitude, longitude, meridians and parallels, the pupil must know about angles and circles.

There is a third reason why geometry is one of the basic subjects taught in high schools. One of its major values is the training it offers in careful and accurate reasoning. This training in reasoning is characteristic not only of the study of geometry but of all mathematical subjects. It is exceedingly valuable in fields outside of mathematics whenever conclusions are to be reached by reasoning from given assumptions.

Trigonometry makes a strong appeal to the high school pupil because it marks an advance step in the acquisition of mathematical power. Procedures previously used in practical problems are tedious and not too accurate. Trigonometry replaces them with simpler and better methods. The following three ways of

solving a problem of finding an unknown distance illustrates what is meant.

Let it be required to find the height of a flagpole. The rope of the flagpole is stretched out until it touches the ground at the endpoint of the shadow of the pole. The pole, the shadow and the rope then form a triangle which we may call the "shadow triangle." We now measure the length of the shadow and one of the two angles at the endpoints, the other being a right angle. With these measurements we can now solve the problem.

1. The geometric method. A second triangle is constructed on level ground by using the length of the shadow and the two angles adjacent to it. By geometry this ground triangle is of the same size and shape as the shadow triangle. The side of the ground triangle corresponding to the flagpole is then measured. This is the required height.

It is evident that the solution is tedious. Moreover, the inaccuracies which occur from the use of instruments in laying off one side and two angles, and from measuring the required side, will affect the accuracy of the result.

2. The algebraic method. Use is here made of a short vertical post and its shadow. Both are measured. The heights of the flagpole and post and the lengths of the two shadows form a proportion which can be solved for the unknown height of the pole.

This method, known as the "shadow method," was used by the Greek mathematician Thales to determine the height of a pyramid. The only errors which may arise come from the measuring of the pole and its shadow. The method is less tedious and more accurate than the geometric method.

3. The trigonometric method. A trigonometric ratio corresponding to the oblique angle of the shadow triangle is read from a trigonometric table. It is then multiplied by the length of the shadow of the pole. This gives the required height.

The only errors introduced in this solution are those of the original measured parts which enter also in the two other methods. Note the simplicity of the process. No construction has to be made and no proportion needs to be set up and solved. All that is required is one arithmetic multiplication.

The fact that the pupils who continue in mathematics realize that they are gaining more and more mathematical power is one of the strong incentives for the study of that subject.

The needs of men and women in the services have disclosed the importance of emphasizing mathematics in the high school

curriculum. Aeronautics, aviation, navigation, ballistics, aerodynamics, meteorology, electricity, radio, topography and map reading are subjects filled with problems which are solved by mathematics. Hence, the requirements of the Army and Navy have stressed the importance of mathematical preparation. Hundreds of thousands of boys and girls preparing to enter the armed services had to present high school mathematics. From the private upward into the higher ranks the demand for mathematics increases from arithmetic to the entire mathematical offering of the high school.

The same need was felt in the industries where the mathematical preparation varies from arithmetic which all workers need to high school mathematics needed by designers, draftsmen and engineers, and to the higher mathematics used by persons engaged in research and by those who design and construct planes, guns, tanks, and ships.

This need will not cease after the war. Extensive plans are under way to convert war industry into peace industry. Great advances are being made in technology. New industries will be created. Transportation by air and water will increase with the expansion of trade with Latin America and the Orient. The need for men to build planes and ships will continue. More research than ever before in time of peace will be carried on. Automobile and radio industries will expand rapidly. The housing industry will grow and with it the demand for modern air conditioning, refrigeration and heating. These advancements will call for more skilled workers: machinists, draftsmen, tool makers, plumbers and electricians. Hence, peace industry's mathematical needs will be no less than those of the armed services and war industries. The demand for mathematical training will increase. Persons seeking employment will have an advantage if they are mathematically prepared. This will apply to boys and girls both.

So far stress has been laid on values of mathematics which prepare the pupil for his future vocation and which will increase his ability to make a living. A discussion of values would be incomplete without including those that contribute particularly to the pupils' general education.

It is commonly recognized that among the principal aims of education should be listed the development of certain important habits and powers. Desirable habits are: orderliness, neatness, accuracy, punctuality, attention to details, reflection, concentra-

tion, overcoming obstacles, carrying tasks to completion, clarity and preciseness of statement. The schools should improve the quality of the pupil's thinking and reasoning and his power of analysis, grasping directions, of using intelligent methods of attack, of exercising judgment, foresight and imagination. The total educational experience must contribute to the realization of these aims, and the teachers of mathematics have been aware of their responsibility. As early as 1923 a National Committee of the National Council of Teachers of Mathematics stated the position of the teachers of mathematics in the following words: To develop powers of understanding and of analyzing relationships of quantity and space; of insight into and control over our environment; of an appreciation of the progress of civilization in its various aspects; and to develop those habits of thought and action which will make these powers effective." Clearly such aims go far beyond the acquisition of subject matter and manipulative skills. The report of this committee has had greater influence on the improvement of the teaching of mathematics than any other single factor. The view is held that mathematics is peculiarly fitted to contribute to those general aims of education. For mathematical work that is not precise and accurate is never acceptable. The constant demand for solving problems and exercises demands a high degree of concentration such as is needed in solving important problems in everyday life. It inculcates in the pupil the desire to overcome obstacles and to carry tasks to completion, once they have been undertaken.

The methods of thinking used over and over in solving mathematical problems are not unlike those employed in solving the problems of everyday life in all fields of activities. Hence, the technique developed through constant practice in mathematics can be applied to the problems which occur in life. In using the technique one may begin with an analysis of conditions. Concepts must be made clear. The known facts must be identified and kept in mind. The relationships involved in the problem must be understood. The facts to be found must be listed. A choice must be made of the most effective procedure leading to the solution. Thinking of this type is necessary in all activities in which difficult problems arise, political, social, industrial, or commercial, and mathematics offers training in it better than any other subject.

The principles and processes of reasoning used in everyday life are the same as those used almost constantly in mathematics,

especially in logical geometry. They cannot be exhibited and taught anywhere better than with the mtaerials of geometry which are so simple that anybody can understand them. It must be assumed that other things being equal, those who have studied the processes are better reasoners than others who have not, and that they can employ them better in non-mathematical situations. People should be able to apply the process of reasoning in presenting their own arguments and in checking the validity of the arguments of others. Discussions in which assumptions have not been clearly stated may lead needlessly to heated arguments. The untrained individual, not knowing what is involved in a proof, falls an easy victim to the "so-called" proofs of propagandists and advertisers because he is not able to detect the hidden assumptions.

If education is to prepare boys and girls for the intelligent performance of their work in adult life they must be "taught" to reason correctly. Mathematics being especially fit to offer training in reasoning makes a significant contribution to education. Nothing should be left out that will equip them to meet life's situations in the best possible way. That is why they need to study mathematics.

(To be continued)

NEW ELECTRONIC DEVICE

The long series of mathematical computations which have been necessary in solving the intricate problems involving the location and arrangement of radio towers are replaced by a new electronic device called the Antennalyzer, Dr. George H. Brown of RCA Laboratories announced today at a meeting of the Washington, D. C., Section of the Institute of Radio Engineers.

Field tests and calculations, which formerly required weeks to perform, are now done in a matter of minutes by this electronic computing machine which adds and sutracts angles, multiplies, looks up trigonometric functions, adds numbers, squares them and finally takes the square root of the whole to produce the desired answer, which the engineers must have to accurately locate a directional radio antenna.

The Antennalyzer—a new magic brain in the field of radio—consists of 52 electron tubes. The associate circuits can be adjusted to duplicate all characteristics of a projected antenna. In operation, the controls of the machine are regulated until a pattern of light on a cathode ray tube is identical with the desired pattern of transmission of the broadcast station. Final dial readings not only tell where to locate the towers, but give all electrical data needed to complete the most efficient antenna design.

THE STORAGE OF PAMPHLETS AND CHARTS

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While the storage of equipment and supplies has not been ignored in the literature of the field, it would seem that there has not been adequate time and attention given to this rather fundamental aspect of science teaching. It seems appropriate to consider briefly the role of storage in the total process of learning.

To the teacher who is interested in the achievement of the scientific method as an outcome of secondary school science courses, it seems axiomatic that in the solution of any problem all the resources which can be brought to bear should be made available. Yet it is a common experience of the science teacher to come upon a certain piece of equipment and realize suddenly that if he had had it in a given situation a few days earlier the learning in that situation would have been greatly improved. A piece of equipment or a book which stands idly on the shelf because the teacher has forgotten or has been unable to locate it had just as well never been obtained. The storage of these resources should be such that their use is suggested rather than that they be forgotten. In fact, it hardly seems to be an overstatement that the science laboratory had just as well not be equipped if the equipment cannot be found, or is not available, or does not suggest itself for use in a learning situation.

Further, it is true that if materials are stored correctly they are stored safely. The materials are protected and the teacher is protected. There are many things in science laboratories which, if improperly cared for, are mutually destructive or create unsafe conditions for students and teacher.

Scientific endeavor can be carried forward most readily where the materials used for that endeavor may be easily found. If they are not readily found the investigations are discouraged. Students who can find or can readily obtain the materials they need for their investigations will explore much more widely and more intelligently than if materials cannot be located, or if too much time is lost in trying to find them.

Finally, orderly storage is economical of both space and time. There are probably few laboratories that do not need to economize on both.

The purpose of the present paper is to consider a system of storage of pamphlets and charts which has been found quite satisfactory. It was found that these materials presented considerable difficulty in storage. Various means of organization were tried but none found to serve the purpose quite so well as that arrangement which is described below.

A combination of pamphlet rack and shelf for charts was devised. The rack was built around a frame of wood of size 2″×4″ according to the drawing in Fig. 1 which shows construction details without certain of the cabinet work which was added to improve its appearance.

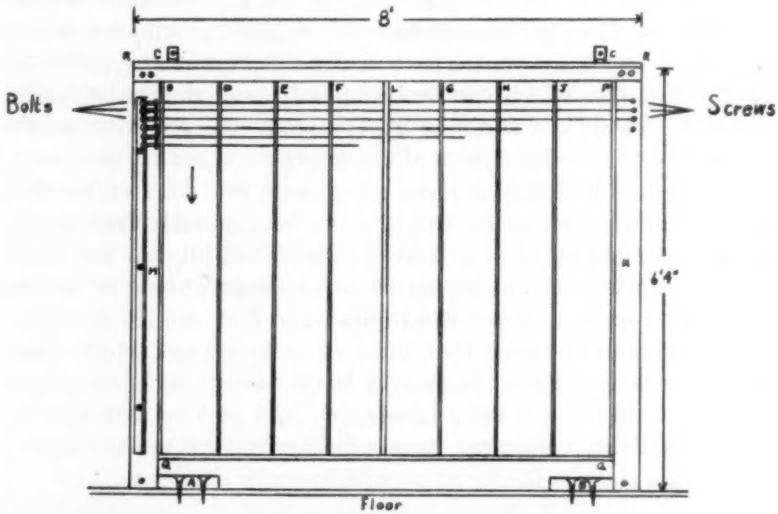


FIG. 1. Front view, construction detail.

CONSTRUCTION FOR PAMPHLETS

Points A and B are anchored to the floor near a wall by means of lag screws and to these short pieces the uprights M and K are bolted. The horizontal piece is bolted to the uprights at points C and C. A plywood back is screwed to the back side of the frame. A board of 8″ width is placed in the position of R R and the frame is anchored at points C and C to the wall. Six vertical supports of lattice are fastened on edge to the front side of the plywood to support wires. These pieces of lattice are designated as D, E, F, G, H, and J. They are placed 11 inches apart, with a corresponding support 1″×2″ at L. At O and P are placed vertical pieces of ½″ thickness and 3″ width. These

are fastened to the frame pieces K and M. These pieces are part of the cabinet work to mask the inner parts of the construction. Because of the inaccessibility of space near the floor all supports stop at a point 6″ above the floor level. A board Q Q is placed in this position as a part of the cabinet work. Holes are drilled through the supports (D, E, F, G, H, J, L, O, P) at intervals of ¾″. The holes are just large enough to accommodate the wire used and are drilled near the outer edge of the lattice pieces so as to leave as much space as possible between the wires and

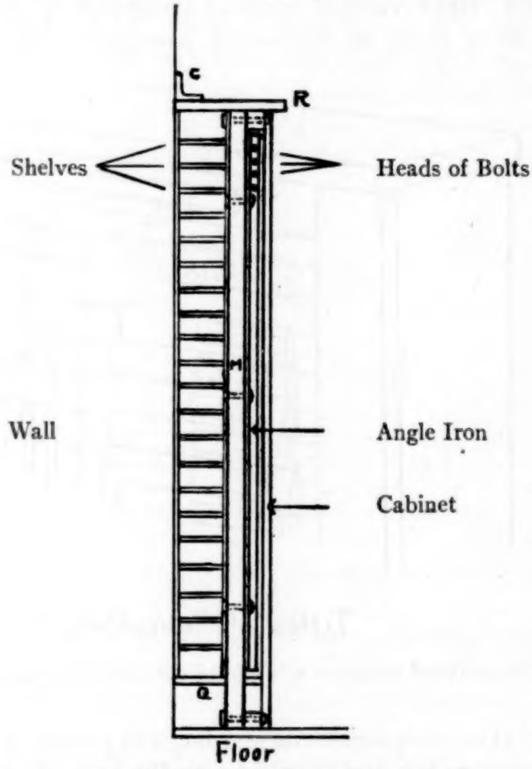


FIG. 2. Left end view, construction detail.

plywood back. Wire of #16 size is used. The wires are anchored by means of heavy screws in the 2″×4″ vertical piece at K. Each wire is then drawn through each piece of lattice in turn and through the 1″ piece at L, and thence through the remaining pieces of lattice to the 2″×4″ piece at M. Upon this 2″×4″ piece is mounted a piece of angle iron of 1¼″ width on each of the sides. Before mounting, holes are drilled through the angle

iron at $\frac{3}{4}''$ intervals to match the holes through the lattice supports. Bolts 3″ long and of 3/16″ diameter with nuts are placed through the holes in the angle iron to be used as a type of turnbuckle. (In Fig. 1 the spacing of these bolts is on an exaggerated scale for greater clarity.) Each wire is drawn up as far as possible and a loop made in the end and wrapped securely back of the nut. By using a screwdriver the bolt is turned, the nut does not, and the wire is drawn taut. In a rack of the height indicated, 83 such wires are placed. There are, as indicated in Figure 1, eight vertical rows of pamphlet space. Each wire serves as a place to support a pamphlet. The pamphlet is

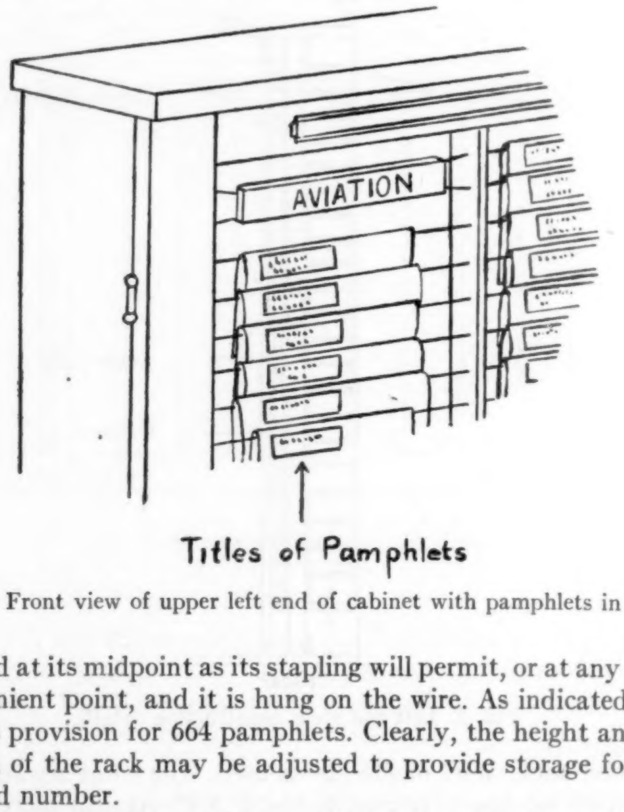


FIG. 3. Front view of upper left end of cabinet with pamphlets in place.

opened at its midpoint as its stapling will permit, or at any other convenient point, and it is hung on the wire. As indicated, this makes provision for 664 pamphlets. Clearly, the height and the length of the rack may be adjusted to provide storage for any desired number.

As the pamphlets are hung on the rack, each above the one below, about $\frac{3}{4}''$ of each of the pamphlets projects as indicated in Figure 3. The lower portion of the pamphlet is behind the titles of the lower pamphlets on the rack. In nearly every case, this method of storage hides the title of the pamphlet, but this

difficulty is readily overcome. The titles to the pamphlets are typed onto gummed labels which are then attached to the pamphlets along the edge which projects; thus, the title of each pamphlet is seen at a glance.

The pamphlets are grouped into certain general divisions which are suggested by the titles and by the nature of the work in the courses; *e.g.*, Industrial Chemistry, Magnetism, Transportation, etc. Those pamphlets in a group are placed on the consecutive wires in a vertical column; each division is headed by its title. A movable device to carry the title is made from a piece of lattice lath of 10″ length. The back side of the lath has four screws not quite screwed down, as indicated in Figure 4. Two of the wires are pulled somewhat closer together as each end of the piece is put into place. The tension of the wires holds the piece in place until it is removed. (Fig. 5) A piece of white

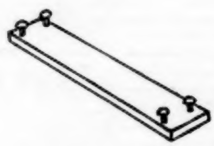


FIG. 4. Reverse side of division title device.

FIG. 5. Showing support of title device by wires.

paper is glued to the front side and the title of the division is lettered on this in letters of large size.

Unfilled spaces are left at the end of each division to provide for expansion. It is sometimes necessary to move an entire group, along with its title, to provide for expansion or regrouping.

The ease of location and examination of any pamphlet is evident. The pamphlets thus become a library resource available to all students as well as the teacher.

A complete listing of all pamphlets and their sources is maintained. As new pamphlets are received their titles and sources are added to the listing. The listing serves as a record, as a means of initial survey in the process of planning, and makes re-ordering possible where additional copies of pamphlets are desired.

Construction for Charts

The space for chart storage is between the pamphlet rack and the wall (Fig. 2). It consists of shelves in the form of long, narrow pigeonholes into which rolled charts are inserted from the end. The upper shelves are 4′ long. The lower shelves extend the length of the rack as indicated in Figure 6.

Both ends of the cabinet are open. Charts are inserted from each end. The open space in the upper part of the right end (as seen from the front) is used to store rigid charts which cannot be rolled and inserted in the pigeonholes.

The shelves are of wood of $\frac{1}{4}''$ thickness and are 4″ wide. They are spaced 3″ apart and are supported at each end by pieces $\frac{1}{4}''$ by 1″. These pieces in turn are fastened to the plywood, and rest on the board Q Q (Fig. 2). There is a total of 32 shelves, 22

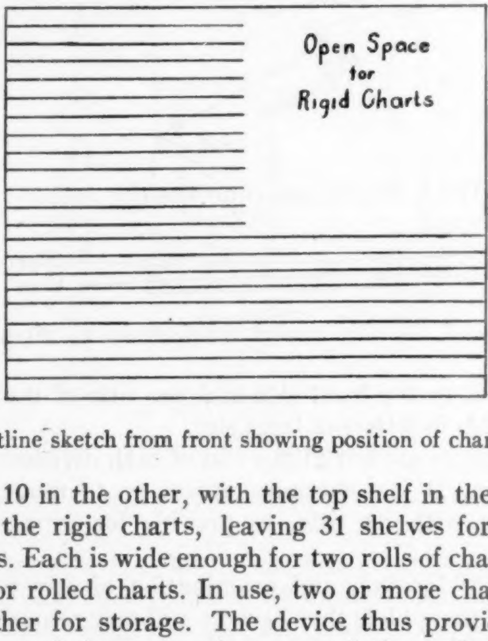


FIG. 6. Outline sketch from front showing position of chart shelving.

in one end, 10 in the other, with the top shelf in the latter case supporting the rigid charts, leaving 31 shelves for storage of rolled charts. Each is wide enough for two rolls of charts, making 62 spaces for rolled charts. In use, two or more charts may be rolled together for storage. The device thus provides storage for a number of charts equal to several times the 62 spaces.

The pamphlet and chart cabinet is finished with facing, molding, and doors to improve its appearance. The completed device is shown in Figure 7. A door on the left end provides access to the chart shelving and to the bolts which are used as turnbuckles to keep the wires taut. There is a corresponding door on the right end to provide access to both the rolled and

the rigid charts. A display rail with a cork center and supplied with clips is placed on the facing just above the pamphlets.

In use, charts are grouped according to certain general areas: Aviation, Electricity, etc. These groups are arranged alphabeti-

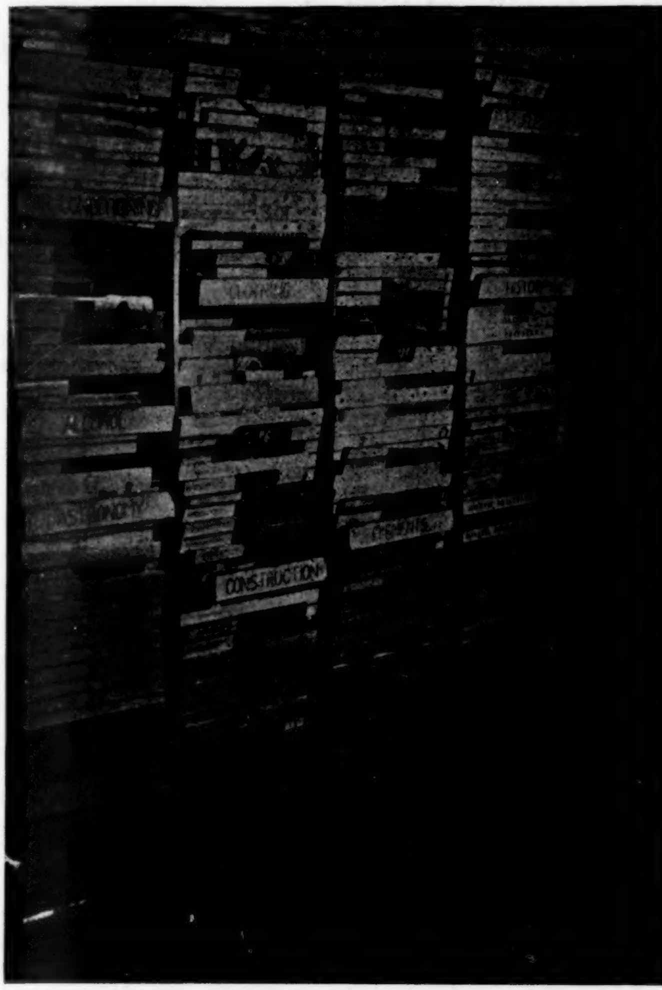


FIG. 7. View of cabinet in use.

cally in the file. Charts which are grouped in the same area are arranged on consecutive shelves. Where two or more charts are rolled together, they are chosen because of the similarity of their contents. Rigid charts are listed with those which are rolled.

The charts are indexed by numbers which are placed on the ends of the shelves. On the door to the file a list of all charts is placed. The title of each chart is followed by the number of the shelf on which it is placed. Rigid charts are indicated by the letter "R" and those which are permanently mounted in the laboratory are indicated by the letter "L." New charts are added as they are obtained. Each is placed in its appropriate group. As the file expands, or as charts are regrouped, they are easily moved from one shelf to another. The index is readily changed, often the only change necessary being the renumbering. Occasionally, it is necessary to retype the index in its entirety, but this is a rather brief task.

A section of the index follows. Because of its length it is not given in full.

	Shelf No.
ELECTROMAGNETIC RADIATIONS	
The Electromagnetic Spectrum	43
Chart of Electromagnetic Radiations	44
HEAT AND ITS TRANSFER	
Ruud Automatic Water Heater	45
Commercial Refrigeration Cycle The Electric Refrigerator	46
LIGHT	
Fluorescent Lamp Pictorial Summary of Light	47
Microscope Charts (3)	48
The New Story of Light	49
Standard Color Chart Color of Sensitivity of Kodachrome Reproduction of Colored Subjects by Kodachrome Characteristics of Yellow Filter, Wratten K-2 Characteristics of Red Filter, Wratten A Wave Lengths in Millimicrons The Visible Spectrum	R
MEASUREMENT	
International Metric System	50
Dimensions of Natural Objects Biggest and Littlest Things of the Universe	51
METALS	
Aluminum	R
From Iron Ore to Finished Automobile	52
Chart on the Metals	53
Manifold Uses of Zinc	54

As indicated in Figure 3, a display rail is mounted above the pamphlet rack. This display rail may be utilized to support the charts while they are being studied. In this institution this device is located in an inner hall leading to an office. The pamphlets and charts are available to students, teachers, and student teachers at any time they are needed. Under other

circumstances it might be desirable to have such storage facilities in the classroom.

Such storage provisions have been found, over a period of years, to make readily available all pamphlets and chart resources. In fact, they are so placed and organized that their use is almost self-suggestive. Each pamphlet or chart has its own place and thus is easily replaced. The materials may be easily reorganized as new resources are acquired and as teaching needs suggest different approaches to learning units.

AMERICAN EDUCATION WEEK

The 25th annual observance of American Education Week will be celebrated November 11–17, 1945. Since its modest beginnings in 1921, American Education Week has come to be a great annual nationwide celebration of the ideals of free public education. It provides an opportunity to interpret to the people the meaning of education for free peoples.

The theme for the 25th observance is "Education to Promote the General Welfare." Concern for the general welfare is the great need of the world today. This is true if individuals are to have happy and challenging lives, if our nation is to find its way to a prosperous and harmonious future, and if the world is to achieve a stable and enduring peace. The schools have a major role to play in developing citizens who will work together for the common good.

World War II will be won, when the final victory is achieved, because we endowed our young men with the best possible training and equipment for war. If this victory is not to be a hollow triumph, we must plan to prepare our young people with equal vigor for the tasks of peace. American Education Week 1945 is an opportunity to stress this idea throughout the nation. America owes it to itself to improve its schools.

Let American Education Week be observed in every classroom, in every school, in every school system, in every state. Let emphasis be placed on the purposes, achievements, and needs of the schools. Let attention be given to the service that they perform for the individual, the community, the state, the nation, and the world.

For a complete list of the materials available to help you in planning your program for American Education Week 1945 write to the National Education Association, 1201 Sixteenth St., N.W., Washington 6, D. C.

PAPER FURNITURE

Fibre reed furniture made of strong twisted paper is sized with animal glue. This protective coating imparts exceptional durability to paper. Clothes hampers, baby carriages, waste paper baskets and other pieces may be made from this treated material.

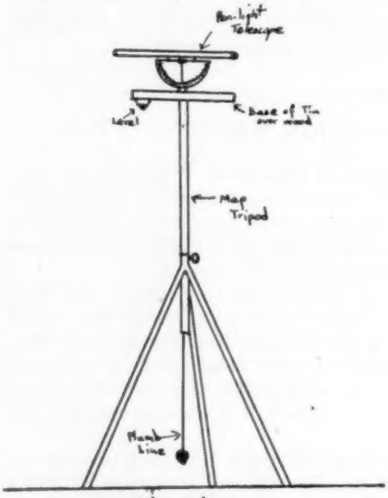
MOTOR OIL IN PAPER CANS

Paper "cans" with a lining of plasticized glue have been used successfully as containers for motor oil.

A HOMEMADE TRANSIT

William F. Goins, Jr.
Hampton Institute, Virginia

Several years ago while instructor of mathematics in a small rural high school, one of the courses offered by the writer included several weeks' work in elementary plane trigonometry.



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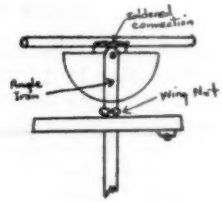

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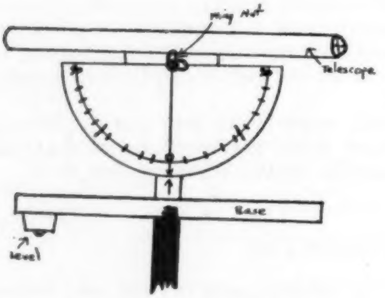
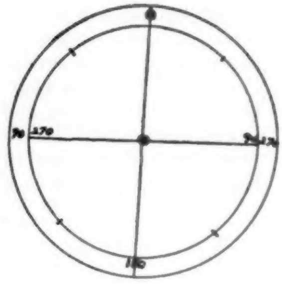


Inclination Circle & Telescope
(Numbered every 10 degrees)



Horizontal Ring Base
(Numbered every 10 degrees)

The course work offered opportunity for practical applications to field problems, and several periods were spent in measuring the school grounds, fence lines, heights of trees, and other simple exercises of a trigonometric nature.

A very limited budget did not permit the purchase of any measuring device as a transit, level, or sextant. Possession of such an instrument would have made such exercises more interesting and more meaningful. Wishing students to get the greatest value from the course despite limitations involved, the writer decided to construct a homemade transit for class use.

In undertaking this project, no formal plans were drafted on paper. A few sketches were made and two lists—one of transit parts, and the other of possible homemade substitutes—were drawn up. These few scraps of paper comprised the drafting stage.

The search for materials proved interesting. Discarded material from trash heaps around the school and in the community turned up an old map stand, a pocket type flashlight case, coffee cans, and an assortment of nuts and bolts. These furnished raw materials for the project. A twenty-five cent spirit level from the dime store completed the list.

The telescope was made from the pen-light case. Both ends were removed and the lens was replaced with a transparent celluloid disc marked with crossed lines. The other end was left open, thus providing a telescope barrel. Since the instrument was to be used over relatively short distances, it was decided that no lens system was necessary.

The horizontal, or azimuth, circle was the next part made. This consisted of a coffee can lid, about six inches in diameter, slipped over a disc cut from a $\frac{3}{4}$ inch board. The center was drilled, and the spirit level attached to the underside. Around the outer edge of the topside, the tin was double-scaled in degrees, and numbered at ten degree intervals. One diameter was deeply scored and marked at each end 0 and 180 degrees, respectively. The double scale provided readings from 0 to 360 degrees both to the right and to the left.

The vertical, or inclination, scale was cut from another coffee can lid. It resembled a protractor of about $2\frac{1}{2}$ inches radius with a strip left on at the diameter for soldering to the telescope barrel. This was double scaled and numbered in ten degree intervals, so that both inclination and declination could be easily read. A hole was drilled in the exact center for fitting with a wing nut and bolt when mounted. The scale was soldered to the barrel and the whole assembly mounted on a small right-angled iron brace in such a manner that the sight line of the telescope was exactly over the diameter of the horizontal plate.

The angle iron was set up with a wing nut so that it would be free to turn horizontally, or could remain stationary.

The whole assembly was mounted at the top of the old map-stand tripod and tested. When used and the results were checked against results from other methods of measurement used with the same problems, it was found that up to distances of one hundred feet azimuthal angles could be read to within one degree, and angles of inclination or declination were accurate within two degrees. The mounting allowed for an inclination of seventy-two degrees and a declination of fifty-five degrees. Traverse was 360 degrees in either direction.

STUDENT ACTIVITIES

Sister M. Stanislaus Costello
620 W. Belmont Ave., Chicago, Illinois

Co-operation among teachers is made possible through the careful perusal of the monthly Jounral, the reading of the articles therein presented by co-workers in the field of science, even though these co-workers are miles and even states apart. To state that School Science and Mathematics is a teacher's aid bears repetition. Scarcely a month passes without the appearance of at least one article full of very useful suggestions for a biology teacher.

It would be well if the journal could become a Teacher-Student publication. In the days of Mr. Franklin Jones, of happy memory, the G.Q.R.A. gave to students the chance to ask or answer scientific questions. It brought the teacher and her students in closer contact with other teachers and their students. In that way the idea of students can be interchanged with fellow students in different parts of the country. That is one of the means of arousing interest in science even beyond the four walls of the high school. Teachers should co-operate in the re-establishment of such a section as the G.Q.R.A.

Club activities, too, tend to bring the students of even far distant schools in closer association. Exchanges can and should be made between one club and another. Clubs should be organized in every science department.

Meetings could be held during a class period. If, for instance, the club is an organization of biology students, every part of the club program should center around the subject concerned,

particularly when the meeting is conducted during a regular class session. At roll call each student should give a scientific fact. That fact should be a statement about something learned during the previous month. In that way the roll call part of the meeting is really a review. No repetition of facts should be permitted. Enough information is gained during a month to provide each student with a different fact. Reports, too, should be biological, probably a clipping from a paper, a magazine, or result of research. To liven the meeting two or more parodies of popular songs might be sung. One suggestion is that the club have a theme song, a parody to a popular song well liked. Each month a new parody could be presented as a second song. In that way meetings can be made interesting as well as educational.

To arouse further interest, a point system is suggested. At the close of the semester, prizes might be awarded, according to the points gained. In that case, dues of two to three cents per month would probably be necessary. The writer has carried through the club idea and found it to be very satisfactory. The scientific fact without repetition, biological reports, the writing of parodies to popular songs of the day kept the students, as it were, on their toes.

Correspondence with other clubs either as a unit or with individuals is another incentive for arousing interest. No doubt most science teachers correlate English and science by assigning themes now and then. The best themes might be kept for a year book. It is the opinion of the writer that every student should be represented in that book at least once. That, too, has been tried and proved to be valuable. Surely, during a five month period each student can submit a satisfactory theme but, if a ten month period is granted, there is absolutely no reason why each student can not be represented in that book of themes. Another suggestion is to exchange such collections with the clubs of other schools. Such a project is all "wrapped up" with interest, and is worth the trial.

Finally, it is through the careful, attentive reading of the Journal that a teacher becomes aware of what is being done by others. Often the application of suggestions offered by others can and does reap abundant fruit. "In unity there is strength."

Let all co-operate for united effort by reading, by offering suggestions, by encouraging student participation, and by club correspondence.

NOTES FROM A MATHEMATICS CLASSROOM

JOSEPH A. NYBERG
Hyde Park High School, Chicago

103. Skill in Computing Is Not Enough. When the checker at the cash register rang up 59 cents for the honey-dew melon, the customer protested, saying, "They are only 45 cents today." The clerk admitted the error, reached for some paper and subtracted 45 from 59, getting 14. She remembered well the admonitions of her arithmetic teacher and so she added 14 to 45 getting 59. Then she did the subtracting once more, and this time checked by adding 45 to 14.

"I guess I owe you 14 cents," she said to the customer, extracted 14 cents from the cash box and handed them to the customer. "And now you owe me 45 cents for the melon."

The customer looked a bit puzzled. "Can't you see that?" said the clerk. "I rang up 59 cents, but the melon costs only 45. I gave you the 14 cents, didn't I? And now you owe me 45 cents for the melon."

So the customer handed the clerk 45 cents. After all, $59-45$ is certainly 14.

If I had not known the characters in the incident I would have said that this was just another story invented by a fertile mind to illustrate a moral. We have all heard many such. I mention some of those that pupils bring to class every year:

1. A man sold a horse for $90, and then bought the horse back for $80, and later resold the horse for $100. How much did the man make by these deals? It is easy to subtract 80 from 90, and 80 from 100, but skill in subtracting is not enough to answer the question correctly.

2. Three men when leaving a hotel each gave the bellboy $10 with which to pay their bill. When the bellboy found that the bill was only $25 he pocketed $2 and returned a dollar to each of the men. Evidently the men paid $27 for their accomodations, and the bellboy got $2. But $30-(27+2)$ is 1. What happened to that other dollar?

3. Bill Jones wanted a new hat; it cost $3 but he had only $2. So Bill went to a pawnshop and pawned the $2 for $1.50. Then he sold the $2 ticket for $1.50. Evidently with the $1.50 received from the pawnbroker, and the $1.50 received by the sale of the pawn ticket, he had enough to buy the hat. But there must be a

catch someplace; otherwise we would all visit a pawnbroker oftener.

4. A customer at a grocery store buys $4 worth of goods and offers a $10 bill. The clerk, having no change, obtains some at the butcher's next door, gives the customer $7 and places $3 in the cash drawer. But the butcher discovers that the $10 bill is counterfeit, whereupon the grocer exchanges it for a good $10 bill. How much has the grocer lost?

Finally consider the following item which is a statement by one of America's foremost educators; it is a footnote on p. 236 of *Foundations of Democracy* by T. V. Smith and Robt. A. Taft. The footnote reads:

"The first world war cost 400 billion dollars. With that money we could have built a $2500 house, furnished it with $1000 worth of furniture, placed it on 5 acres of land, worth $100 an acre, and given this home to each and every family in the United States, Canada, Australia, England, Wales, Scotland, Belgium, Germany, and Russia. We could have given to each city of 200,000 inhabitants or over, in each country named, a five million dollar library, a 5 million dollar hospital, and a 10 million dollar university."

The footnote also mentions some more benefactions. We may assume that the computations are correct. But I am interested in knowing how many towns of 200,000 inhabitants there could be if *every* family in a country is put on a five acre lot?

A problem of arithmetic involves two things: (1) ability to compute, and (2) understanding the problem well enough to know which operation (addition, subtraction, multiplication, and so forth) to perform. There is also a third step, namely, interpreting the results; but that is often a problem for the class in social studies. I grant that you cannot do step (2) unless you can do step (1), but skill in computing is not enough.

It seems that so much emphasis is put on step (1) that there is little time left to learn step (2). But step (1) is of no value unless it is applied in step (2). Would it not be better to know a little less, or much less, of the first step in order to learn a little more of the second step? Textbooks in arithmetic for the grammar school include material for both steps, but the so-called maintenance work in high school concentrates on the computations. Further, even if much more work on the second step were provided in high school texts, many teachers would omit it. Their usual cry is "Pupils can't do that work; it's

hopeless." Teachers, like pupils or any other workers, are discouraged by failure and encouraged by success. After struggling for a week trying to teach pupils the second step, and after seeing little evidence of improvement, the teacher goes back to the drilling in step (1) in which the improvement is at once evident. How can our Teachers Colleges teach future teachers the art of persevering on a right course in the face of discouragement? The aptitude tests that select teachers should include as a factor: the courage to do the right thing. Since this is difficult, I offer another suggestion: Can the material in arithmetic be so arranged that the class and the teacher do get a feeling of success and are thereby encouraged to travel the right road? When an algebra class shows any sign of being discouraged, I do not preach to them about the beauties of mathematics or its importance to civilization; we have a short (ten minute) test, in which the problems are all so easy that almost every pupil scores 100. Being thus encouraged, they are ready to resume the attack.

What I have said about steps (1) and (2) applies to algebra also. When I ask teachers why they spend so much time on step (1) the answer is invariably, "If they know the operations well, the pupils can easily learn everything else." But I do not believe this is true; the second step is a slow growth and there must be practice every week of the year.

104. The Validity of some tests. Perhaps the following experiment has been made; if so, I would like some information about it. Gather two groups of pupils, establish their equality, find their I.Q., and so forth, and give each a test in arithmetic. To one group give exercises like:

1. Add $\frac{1}{2}$ and $\frac{1}{3}$. 2. Multiply $2\frac{1}{2}$ by $3\frac{1}{2}$.

and similar exercises such as are used to determine a pupil's ability to compute, or knowledge of the operations.

Let the other group have problems like:

1. While training for the track team, Jim one day ran $\frac{1}{2}$ mi. and later ran $\frac{1}{3}$ mi. What is the total distance he ran?

2. Jim works for an A.P. store during vacations. He gets $\$3\frac{1}{2}$ a day. One week he was sick and could work only $2\frac{1}{2}$ days. How much did he earn that week from this store?

Note that in each group identically the same numbers are used; but in one case the problem is stated abstractly, and in the other a concrete setting close to the pupil's interests and

environment is used. The second group has the disadvantage of needing more time to read the problem but this difference is slight. Further, pupils in the second group are not told which operation to perform. But I venture the guess that (all other things being equal) the second group will do better than the first.

This guess is based on the belief that many pupils who add $\frac{1}{2}$ and $\frac{1}{3}$ incorrectly on examinations can find the correct sum easily when confronted with a situation that is of some importance to them. And when it is a matter of dollars and cents and affects their own pocketbook they seem to get the right answer. Perhaps the pupils are not so ignorant of arithmetic as the tests indicate.

In my own classes I have tried this experiment: Give a 15 minute test in arithmetic, mark it, and set it aside. A month later give exactly the same test and announce that pupils who make a certain score will be excused from doing all home work for a week. Compare the results on the two tests. I do not think the country is in such a deplorable condition as some writers would have us believe.

105. Comparing Areas and Volumes. Many theorems dealing with mensuration have corollaries like:

Triangles with equal bases are to each other as their altitudes.

Two parallelograms having equal bases have the same ratio as their altitudes.

Two parallelepipeds have the same ratio as the products of their three dimensions.

The areas of two spheres are to each other as the squares of their radii.

(Incidentally, I prefer to say *the ratio of* rather than use that pesuliar phrase *are to each other as*. The first phrase is mathematical; the second sounds like a study of human behavior.)

When these statements are inserted as corollaries, they are likely to be neglected. Even if not omitted, as they often are, the treatment of one at a time makes little impression on the pupil. The comparisons deserve to be grouped together and treated as a whole. One day can be devoted to comparing areas: How is the area changed if this line or that line is changed? And in solid geometry classes: How is the volume changed by a change in this or that quantity? In addition to the corollaries like those quoted above, many other comparisons should be considered.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1917, 1921, 3. *Alan Wayne, Flushing, N. Y.*

1921, 3. *Helen M. Scott, Baltimore, Md.*

1927. *Proposed by Howard D. Grossman, New York City.*

Show that an array of $N\cdot N$ squares contains $1^3+2^3+3^3+\cdots+N^3$ rectangles, of which $1^2+2^2+3^2+\cdots+N^2$ are squares.

Solution by Aaron Buchman, Buffalo, N. Y.

From a line segment consisting of N intervals, there are evidently $(a+1)$ ways of picking a segment consisting of $(N-a)$ such intervals, where $0\leq a<N$.

Thus the total number of segments consisting of any number of intervals from 1 to N, that can be picked from the line segment of N intervals is given by the sum,

$$S=1+2+3+\cdots+N=\frac{N(N+1)}{2}. \tag{1}$$

Now let two line segments each consisting of N equal intervals be layed off at right angles from the same point. Choose a sub-segment in each line segment, and let each sub-segment project a shadow at right angles to itself. The area common to these two shadows will be one of the required rectangles.

From equation (1), the total number, T, of such rectangles is given by the relation,

$$T=\frac{N(N+1)}{2}\cdot\frac{N(N+1)}{2}=\frac{N^2(N+1)^2}{4}.$$

But it is easily shown by mathematical induction that

$$1^3+2^3+3^3+\cdots+N^3=\frac{N^2(N+1)^2}{4}=T. \tag{2}$$

There are evidently $(a+1)(a+1)=(a+1)^2$ ways of forming a square of side $(N-a)$ in the above manner.

Thus the total number of squares that can be formed is given by the relation,

$$T_{\text{square}}=1^2+2^2+3^2+\cdots+N^2. \tag{3}$$

Solutions were also offered by Milton Schiffenbauer, Camp Walters, Texas; Brother Felix John, Philadelphia, Pa.; Clarence R. Perisho, McCook, Neb.; Brother U. Alfred, Napa, Calif.

1928. *Proposed by Hugo Brandt, Chicago, Ill.*

Show that

$$\sum_1^n n^5+\sum_1^n n^7=2\left[\sum_1^n n\right]^4.$$

Solution by J. F. Arena, State Teachers College, Boone, N. C.

From Hall and Knight's *Higher Algebra*, Fourth Edition, Art. 406, we have the following formula for the sum of the pth power of the natural numbers:

$$\sum_1^n n^p=\frac{n^{p+1}}{p+1}+\frac{n^p}{2}+B_1\,\frac{pn^{p-1}}{2!}+B_3\,\frac{p(p-1)(p-2)n^{p-3}}{4!}$$
$$+B_5\,\frac{p(p-1)(p-2)(p-3)(p-4)n^{p-5}}{6!}+\cdots$$

where

$$B_1=\frac{1}{6},\ B_3=-\frac{1}{30},\ B_5=\frac{1}{42},\ B_7=-\frac{1}{30},\cdots$$

Putting $p=5$ and then $p=7$ in this formula, we obtain

$$\sum_1^n n^5=\frac{1}{12}\,(2n^6+6n^5+5n^4-n^2)$$

$$\sum_1^n n^7=\frac{1}{24}\,(3n^8+12n^7+14n^6-7n^4+2n^2)$$

$$\therefore\ \sum_1^n n^5+\sum_1^n n^7=\frac{1}{24}\,(3n^8+12n^7+18n^6+12n^5+3n^4)$$
$$=\frac{n^4}{8}\,(n^4+4n^3+6n^2+4n+1)$$
$$=\frac{n^4}{8}\,(n+1)^4=2\left[\frac{n}{2}\,(n+1)\right]^4$$
$$=2\left[\sum_1^n n\right]^4.$$

Solutions were also offered by Brother Felix John, Philadelphia, Pa.; Morris I. Chernofsky, New York City; Brother U. Alfred, Napa, Calif.;

Roy Dubisch, Missoula, Mont.; Alan Wayne, Flushing, N. Y.; Milton Schiffenbauer, Camp Wolters, Texas and the proposer.

1929. *Proposed by Norman Anning, University of Michigan.*

Construct a homogeneous function of 3rd degree of sin A, sin $3A$, sin $4A$, which shall be identically zero.

Solution by Brother U. Alfred, Mont La Salle, Napa, Calif.

$$\sin 3A = 3 \sin A - 4 \sin^3 A$$

$$\sin 4A = 4 \sin A \cos A - 8 \sin^3 A \cos A.$$

The form of sin $4A$ indicates that we have to square it to get over into the sin function. For the third degree, multiply by sin A. Then

$$\sin A \sin^2 4A = 16 \sin^3 A - 80 \sin^5 A + 128 \sin^7 A - 64 \sin^9 A$$

Subtracting $\sin^3 3A = 27 \sin^3 A - 108 \sin^5 A + 144 \sin^7 A - 64 \sin^9 A$ we obtain:

$$\sin A \sin^2 4A - \sin^3 3A = -11 \sin^3 A + 28 \sin^5 A - 16 \sin^7 A$$

Adding $\sin A \sin^2 3A$ gives

$$\sin A \sin^2 4A - \sin^3 3A + \sin A \sin^2 3A = -2 \sin^3 A + 4 \sin^5 A.$$

Two more obvious steps of the same sort lead finally to the relation:

$$\sin A \sin^2 4A - \sin^3 3A + \sin A \sin^2 3A + \sin^2 A \sin 3A - \sin^3 A = 0.$$

1930. The statement of this problem is not in general true, with the following named people contributing:

C. R. Perisho, McCook, Neb.; Brother Felix John, Philadelphia, Pa.; Margaret Joseph, Milwaukee, Wis.; Aaron Buchman, Buffalo, N. Y.; Ronald Henderson, Paxton, Ill.; Louis Moskowitz, Brooklyn, N. Y.; W. R. Warne, Columbia, Mo.; Roy Dubisch, Missoula, Mont.

The problem, correctly stated will appear later as 1982. The Editor made the error.

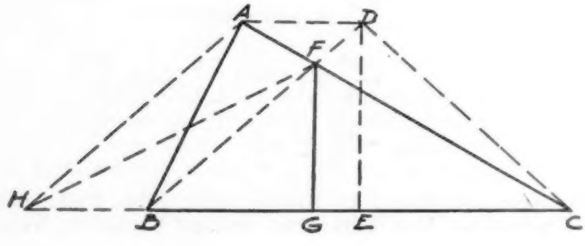
1931. *Proposed by C. R. Perisho, McCook, Neb.*

Construct a line perpendicular to the base of a triangle that will bisect the area of the triangle.

First Solution by Helen McScott, Baltimore, Md.

Let ABC be the given triangle. Draw DBC isosceles on $BC = ABC$. Convert $AFGB$ into equivalent triangle FHG. Hence by simple geometry we have

$$\triangle FBH = \triangle AFB = \triangle DFC$$



and also

$$\triangle FHC = \triangle DBC$$

and

$$AH = DC$$

hence

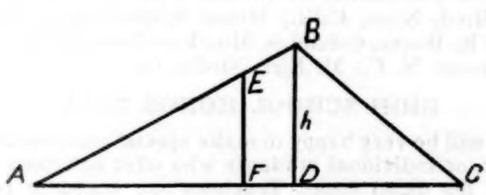
$$FH = FC$$

and FG bisects ABC

Second Solution by Alan Wayne, Flushing, New York.

Let AC be the base of triangle ABC. Draw altitude BD perpendicular to AC at D. In AC locate point F so that AF is the mean proportional to $\frac{1}{2}AC$ and AD. Then the line FE perpendicular to AC bisects triangle ABC. Proof: from construction,

$$2AF/AD = AC/AF. \tag{1}$$



By similar triangles,

$$AD/AB = AF/AE. \tag{2}$$

Multiplying (1) and (2)

$$2AF/AB = AC/AE, \quad \text{whence} \quad (AF \cdot AE)/(AC \cdot AB) = \tfrac{1}{2};$$

but two triangles which have an angle of one equal to an angle of the other have the same ratio as the products of the sides including the equal angles, hence

$$(\text{triangle } ADE)/(\text{triangle } ABC) = \tfrac{1}{2}.$$

Other solutions were offered by Brother U. Alfred, Napa, Calif.; M. Kirk, Media, Pa.; Lois Kragenbring, Interlaken, N. Y.; W. R. Warne, Columbia, Mo.; D. F. Wallace, St. Paul, Minn.; Grace Marsh, Atlantic City, N. J.; Emma Everts, Kinney's Hollow, N. Y.; B. Felix John, Philadelphia, Pa.; Aaron Buchman, Buffalo, N. Y.; Clarence R. Perisho, McCook, Neb.; Milton Schiffenbauer, Camp Wolters, Texas.

1932. *Proposed by Felix John, Philadelphia, Pa.*

Solve the equation

$$\sqrt[m]{(a+x)^2}+2\sqrt[m]{(a-x)^2}=3\sqrt[m]{a^2-x^2}.$$

Solution by Hazel S. Wilson, Annapolis, Md.

$$\sqrt[m]{(a+x)^2}+2\sqrt[m]{(a-x)^2}=3\sqrt[m]{a^2-x^2}. \tag{1}$$

Set $u=(a+x)^{1/m}$, $v=(a-x)^{1/m}$. Then (1) becomes

$$u^2+2v^2=3uv$$

$$u^2-3uv+2v^2=0$$
$$(u-2v)(u-v)=0$$
$$u=v, \quad u=2v$$
$$u=v, \text{ gives}$$
$$(a+x)^{1/m}=(a-x)^{1/m}$$
$$a+x=a-x, \text{ whence}$$
$$x=0$$
$$u=2v, \text{ gives}$$
$$(a+x)^{1/m}=2(a-x)^{1/m}$$
$$a+x=2^m(a-x)$$
$$x(1+2^m)=2^m\cdot a-a$$
$$x=\frac{a(2^m-1)}{2^m+1}\cdot \quad \text{Both}$$

Solutions were also offered by Brother Felix John, Philadelphia, Pa.; Brother U. Alfred, Napa, Calif.; Milton Schiffenbauer, Camp Wolters, Texas; Walter R. Warne, Columbia, Mo.; Roy Dubisch, Missoula, Mont.; J. F. Arena, Boone, N. C.; M. Kirk, Media, Pa.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in his department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below.

1931, 2. *David Bailey, West View (Pa.) H. S.*

1935, 8. *William Hasek, West View (Pa.) H. S.*

PROBLEMS FOR SOLUTION

1945. *Proposed by Brother Felix John, Philadelphia, Pa.*

The arithmetic mean between M and N, and the geometric mean between a and b are each equal to $Ma+Nb/M+N$. Find M and N in terms of a and b.

1946. *Proposed by Clarence R. Perisho, McCook, Neb.*

A cylindrical standpipe H feet high stands on level ground and is full of water. At what height above the ground should a hole be drilled so that the horizontal stream of water issuing from the hole will strike the ground at the greatest distance from the base?

1947. *Proposed by W. R. Warne, Marshall, Mo.*

In triangle ABC, with $C=90°$, and ED parallel AC, if $CD=10$, $ED=15$ and if $AB+BC=100$. Find BD.

1948. *Proposed by J. C. Ward, Chicago, Ill.*

The sides AB and AC of a triangle are cut by a line in points M and N respectively, so that $BM=MN=NC$. Construct the line.

1949. *Proposed by Brother U. Alfred, Napa, Calif.*

Find the general form of all fractions in a number system of base, r, that give rise to a pure repeating decimal.

1950. *Proposed by Brother U. Alfred, Mont La Salle, Napa, Calif.*

1. Given any triangle ABC. On AB and AC cut off equal segments from A on the same side of A and connect the end points of the segments by a line. Proceed similarly for the two other pairs of sides. The three lines thus obtained form a triangle.

Operate similarly on this new triangle and continue this process.

What can be said about the angles of the successive triangles thus produced? What sort of triangle is approached in the limit?

BOOKS AND PAMPHLETS RECEIVED

Optical Instruments, by Earle B. Brown, Cloth. Pages xii+567. 13.5×22 cm. 1945. The Chemical Publishing Company, Inc., 234 King Street, Brooklyn, N. Y. Price $10.00.

The Electrolytic Capacitor, by Alexander M. Georgiev, *Member, American Institute of Electrical Engineers.* Cloth. Pages xii+191. 15×23 cm. 1945. Murray Hill Books, Inc., 232 Madison Avenue, New York 10, N. Y. Price $3.00.

An Introduction to Mathematics for Teachers, by Lee Emerson Boyer, *Millersville State Teachers College, Millersville, Pennsylvania.* Cloth. Pages xvii+478. 13.5×21.5 cm. 1945. Henry Holt and Company, Inc., 257 Fourth Avenue, New York 10, N. Y. Price $3.25.

Chemistry: A Course for High Schools, by John C. Hogg, A.M., M.A., *Chairman, Science Department, The Phillips Exeter Academy, Exeter, New Hampshire;* Otis E. Alley, Ph.D., *Head of Science Department, Winchester High School, Massachusetts;* and Charles L. Bickel, Ph.D., *Instructor in Science, The Phillips Exeter Academy, Exeter, New Hampshire.* Cloth. Pages viii+544. 15×23 cm. 1945. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3, N. Y.

Workbook for Chemistry. Pages v+272. Laboratory Exercises for Chemistry. Pages vii+120. Laboratory Manual to Chemistry. Pages vi+105. Written by John C. Hogg, A.M., M.A., *The Phillips Exeter Academy, Exeter, New Hampshire*; Otis E. Alley, Ph.D., *Winchester High School, Winchester, Massachusetts;* and Charles L. Bickel, Ph.D., *The Phillips Exeter Academy, Exeter, New Hampshire.* Paper. 19×27 cm. 1945. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3, N. Y.

Educators Guide to Free Films, Compiled and Edited by Mary Foley Horkheimer, and John W. Diffor, M.A., *Visual Education Director, Randolph High School, Randolph, Wisconsin.* Fifth Edition. Paper. Pages viii+254. 20×27.5 cm. 1945. Educators Progress Service, Randolph, Wis. Price $4.00.

Evidences of Progress on Undertakings. A Symposium Presented at the Eleventh Annual Meeting of The Association of Colleges and Secondary Schools for Negroes held at South Carolina State A. and M. College, Orangeburg, South Carolina, December 7–8, 1944. Paper. Pages iii+60. 15×23 cm. The Secondary School Study, 113 Administration Building, Atlanta University, Atlanta, Ga.

Progress and Plans of Negro High Schools Toward Regional Accreditment. Paper. Pages vii+43. 15+23 cm. 1944–1945. Copies of this

Report can be secured by request from L. S. Cozart, *Secretary, Association of Colleges and Secondary Schools for Negroes, Barber Scotia College, Concord, N. C.*

School Census, Compulsory Education, Child Labor: State Laws and Regulations, by Maris M. Proffitt, *Chief, Division of General Instructional Services,* and David Segel, *Senior Specialist in Tests and Measurements.* Bulletin 1945, No. 1. Pages iv+200. 14.5×23 cm. For Sale by the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. Price 30 cents.

BOOK REVIEWS

Principles of Radio, by Keith Kenney, *Editor of Electronics, Fellow Institute of Radio Engineers.* Fifth Edition. Cloth. Pages viii+534. 13×19.5 cm. 1945. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $3.50.

This new edition of a book that has been a favorite of many for years is a real revision. The first few pages, which in the previous editions contained many errors, have been completely rewritten. Much of the remainder of the book also appears in an entirely new and improved arrangement. New material has been added to assist the student in obtaining a mastery of the fundamentals and to cover recent developments in theory and practice. Additional work is given on measuring instruments, magnetic circuits, Kirchoff's laws and power factor, thus providing the student with a better foundation for later radio work. Improvements have been made in the discussions of vacuum tube voltmeters, cathode ray oscillographs, filter design for power supply, quarter- and half-wave transmission lines, filter circuits, and many other topics. Entirely new discussions include ultra high frequency apparatus, frequency modulation, Klystrons, and velocity modulation tubes. The new edition is no larger than the previous one; many of the less important topics have been shortened or omitted entirely.

The general form of the book has been retained. Excellent diagrams and graphs illustrate important topics and clarify the discussion. Numerical problems, some solved and some for student solution, are numerous in the first half of the book where electrical principles predominate. Radio teachers will find it an excellent text for elementary college or the better high school classes.

G. W. W.

The Chemical Formulary, by Editor-in-Chief, H. Bennett. Volume VII. Cloth. Pages xxxii+474. 13.5×21.5 cm. 1945. The Chemical Publishing Company, Inc., 234 King Street, Brooklyn, N. Y. Price $6.00.

This volume is one of a series which may be used as a set, but this one was especially designed for the general public, and contains many formulas for the housewife, the farmer, the painter, the textile worker, and for nearly everyone else. Its table of contents lists twenty groups in the following chapter headings: Adhesives; flavors and beverages; cosmetics and drug products; emulsions and colloids; farm and garden specialties; food products; inks and marking substances; skins—leather and fur; lubricants and oils; materials of construction; metals and alloys; paint, varnish, lacquer and other coatings; paper; photography; polishes; pyrotechnics and explosives; plastics, resins, rubber, wax; soap and cleaners; textiles and fibers; miscellaneous.

By the inexperienced the introductory chapter should be thoroughly studied and its instructions followed. Others can go at once to the chapter of their interest where they will find many recipes for making the products they need. In addition to the chapters listed above the book contains important tables of weights and measures, introconversion tables, a table of thermometer readings F° and C°, alcohol proof and percentage table, and an elaborate list of chemicals and supplies and where to buy them. The editors are leading chemists from the important chemical industries and many university professors. Whether you are an industrial chemist, a manufacturer, a technical worker, an instructor, or a layman the book will give you much information of value in your work.

G. W. W.

DICTIONARY OF ENGINEERING AND MACHINE SHOP TERMS, by A. H. Sandy, *Silver Medalist, City and Guilds of London; Instructor and Lecturer, Mechanical Engineering Department, Borough Polytechnic, London.* Revised by I. E. Berck, Ph.D. Cloth. 153 pages. 13.5×21.5 cm. 1944. The Chemical Publishing Company, Inc., 26 Court Street, Brooklyn 2, N. Y. Price $2.75.

Here is a book for the engineer, for the foreman in a machine shop, for the teacher in the small shop or laboratory, or for the ordinary workman who must use or order tools. Many of the words used in industry have specialized meanings which often lead the uninitiated into wrong channels. Can you define a riser, or a poppet, or a pinion? Do you know the difference between a billet and a bloom, or a bastard cut file and a second cut file? What is a Tommy bar? A rose bit? This little book does not explain every mysterious expression of the shop man but it will help the amateur in many cases. No doubt many would like to have more definite descriptions with illustrations.

G. W. W.

THEORY OF FUNCTIONS, by Dr. Konrad Knopp, *Professor of Mathematics at the University of Tübingen;* translated by Frederick Bagemihl, M. A., *Instructor in Mathematics at the University of Rochester.* Part One—Elements of the General Theory of Analytic Functions. Cloth. Pages vii+146. 11×17.5 cm. 1945. Dover Publications, 1780 Broadway, New York 19, N. Y. Price $1.25.

This little monograph, approximately a centimeter in thickness, is a delightful surprise when one finds an almost unbelievable amount of material for such a small book. The author has managed to combine clarity and conciseness with rigor. In particular the use of well chosen illustrations helps in the presentation of many points. The sub-title might have read—Functions of a Complex Variable. The treatment, in concise but very readable form, covers this topic rather thoroughly, including integral theorems, series and expansion in series, singularities. Although the topics are reviewed early in the text, it is assumed that the reader has sufficient mathematical maturity to be familiar with calculus and the theory of real numbers. The book contains a brief bibliography and an index. It would be difficult to find elsewhere as complete and rigorous a treatment in anything like this number of small pages.

CECIL B. READ
University of Wichita

FUNDAMENTALS OF ALGEBRA, *Second Book*, by Joseph A. Nyberg, *Instructor in Mathematics, Hyde Park High School, Chicago.* Cloth. Pages v+405. 14×18.5 cm. American Book Company, New York.

This text is planned so that it may be used for either a half-year or a full-year course. In many cases material is so arranged that the instructor may have the option of omitting entire chapters or omitting less fundamental material which is given at the end of the chapter. A valuable feature, which takes care in planning the text, is the arrangement of material so that when the pupil opens his book to work on exercises, the explanatory material is always visible at the same time.

In many places the text assumes the pupil has had a course in geometry. It is doubtful if this book would be satisfactory in a situation where pupils may take a second course in algebra without a geometry requirement. The arrangement of material is at times a refreshing departure from tradition, for example one finds synthetic division covered on page 24. There are several exceptionally well chosen full page pictures illustrating the use of mathematics in science and industry. There seems to be an ample supply of problems, with answers for essentially all of them. In several places there are interesting historical notes. Tables included are of powers and roots, trigonometric ratios to four decimal places for every ten minutes; four place logarithms of trigonometric ratios to ten minute intervals, and a four place logarithm table.

It is unusual to find a text with as clear a discussion of multiplication and division of complex numbers (page 180). In dealing with negative and zero exponents, although the author points out that certain operations are impossible if the base is zero, he does not make the explicit statement that the definitions are not valid for a base of zero; he likewise fails to make clear what restrictions are necessary to give a unique meaning to a fractional exponent. In discussing maxima and minima on page 214, the student might get the erroneous impression that the maximum value of a function always occurs halfway between points where the curve of the function crosses the x-axis. (The author does not clarify the point that this is a parabola.) Some teachers might prefer that another method of evaluating a third order determinant might be presented in addition to the use of minors.

Most of the points mentioned are of minor importance—the text is very definitely worth consideration.

CECIL B. READ

BETTER COLLEGES—BETTER TEACHERS, by Russell M. Cooper and Collaborators of 28 Colleges. Paper. Pages viii+167. 15×23 cm. 1944. North Central Association Committee on the Preparation of High School Teachers in College of Liberal Arts. Distributed by The Macmillan Company.

This booklet covers a cooperative venture by several colleges during a two year period and deals specifically with the education of teachers. It sets forth what individual colleges have done, what results were achieved, and describes objectives. Among the topics discussed are the question of the meaning of objectives of a college, and the extent to which objectives are attained; building the college curriculum; the improvement of college instruction; the college personnel program.

Whether or not one agrees with all the statements made, it would seem doubtful that one is justified in discussing the important problem of teacher preparation without being familiar with the results obtained in this cooperative program of study. The report is worth reading and re-reading. Although the table of contents is rather detailed, the reviewer found the lack of an index bothersome when he tried to again locate a passage which impressed him on first reading.

CECIL B. READ

Demonstrations and Laboratory Experiences in the Science of Aeronautics, A Guide for Teachers and Students, Prepared with the Cooperation of The Civil Aeronautics Administration and the American Council on Education. Contributing Authors: H. C. Christofferson, *Chairman of Committee, Professor of Mathematics and Director of Secondary Education, Miami University;* Guybert P. Cahoon, *Professor of Education, Ohio State University;* J. S. Richardson, *Associate Professor of Education and Principal of McGuffey Schools, Miami University;* Frank M. Fairchild, *Coordinator, Department of Vocational Education Trades and Industries, Cincinnati Public Schools;* Merrill Hamburg, *Director of Vocational Education, Detroit Public Schools.* Cloth. Pages viii+155. 22×28 cm. 1945. McGraw Hill Book Company, 330 West 42nd Street, New York 18, N. Y. Price $2.00.

This book is an attempt to meet the demand for a compilation of devices and activities utilizing simple, easily available materials; which may in many cases be constructed by students, at least require no complicated techniques or skills; and can be carried out in a reasonably short time. In many cases two or more alternate devices for demonstrating a given principle are given; frequently the suggestion is made that other materials could be used. To a large extent the materials needed are readily available, although the last chapter describes several more elaborate models which require some skill in the use of woodworking machinery.

The devices described range from the use of a book and sheet of thin paper for demonstrating the Bernoulli principle to a model wind tunnel, requiring 16 pages and over 50 drawings to explain the construction. It is hard to see how any teacher of aeronautics could afford to be without this book. Even if money is available for expensive commercial apparatus, the student may gain much more insight into the principle by the construction of a simple model.

Doubtless many teachers could add additional devices, some of which may be an improvement—such additions may be made in later editions. Again, some may not like certain suggested devices or activities—this in no manner detracts from the value of the book as a whole. For example, the purist may well question how (as instructed on page 9) a hole is to be drilled in which a pivot fits without friction; he may object to the use of the words X-Ray in describing a device for checking scale drawings when no use whatever is made of X-Rays. (Another objection might be voiced from the point of view that for this device to be useful, each student must use identical scales in making the drawings.) Some one may prefer a different type of circular slide rule. In some localities the local fire laws would prohibit the use of the device described on page 48–49 for a combustion demonstration. All of these objections are really of little importance in the light of the main purpose of the book, which has been admirably accomplished—certainly there is little else available giving such material.

Some idea of the scope of material covered may be indicated by listing a few section headings with the pages devoted to each: Aerodynamics, 39 pages; Power Plants, 6 pages; Meteorology, 28 pages; Navigation, 29 pages; Communications, 4 pages.

The typography is excellent, illustrations are well made, and the instructions seem on the whole very easy to follow.

Cecil B. Read

Glue impregnated paper gaskets are used today on all jeep, tank, and airplane motors. This flexible, easily processed material is said to offer a tight seal, is easily removed, does not flux to metal, and is more vibration proof than regular gasket materials.

BILL OF RIGHTS OF TEACHERS OF SECONDARY MATHEMATICS

A Bill of Rights for the teacher of mathematics has a two-fold purpose. First it should declare his right to an *opportunity* for adequate preparation for the tasks which lie ahead. Second it should set forth his right to share fully in the *responsibility* associated with being a teacher of mathematics.

The nature of mathematics and its uses in the work-a-day world can be made of primary significance. This can be done by facing the facts with intelligence, courage, and patience. There is a desperate need for a meaningful understanding of relationships (both arithmetical and functional) as well as of the techniques of mathematical manipulation. The quantitative aspect of our current living offers both the opportunity and the responsibility for a fuller understanding through the mode of analysis commonly called mathematics.

Accordingly we believe a teacher of secondary mathematics has two sets of rights:

A. Those relating to opportunity:
1. To expect colleges and universities to offer mathematics courses of more functional value than is being done.
2. To study at first-hand the applications of mathematics to science, engineering, social science and government under competent instructors.
3. To have experience in business, in industry, and in government in order to become familiar with current practices in applications of mathematics.
4. To expect that school boards will provide financial assistance for teachers to visit other schools and attend conferences and institutes.
5. To expect encouragement from school administrators for needful experimentation with recent developments in content materials and methods of instruction.
6. To expect a salary commensurate with his training and his responsibilities.
7. To have access to a mathematics laboratory with its library, illustrative devices, mathematical instruments, and teaching aids for classroom use.
8. To participate in curriculum building and adaptation of the curriculum to his students in mathematics and in the selection of textbooks.
9. To have satisfactory tenure provisions, and adequate certification standards.

B. Those relating to responsibility:
1. To acquire the knowledge and the skills needed in assisting students to understand and appreciate mathematics.
2. To become familiar with the vocational opportunities in his field and in related fields in order to guide students intelligently.
3. To see that students realize the broad objectives essential to good citizenship and satisfactory vocational performances.
4. To help establish and maintain high standards of excellence in teaching.
5. To encourage students to broaden their horizons by investigating quantitative relationships wherever they may be found.
6. To participate cooperatively in the best available in-service training.
7. To be familiar with the historical development of mathematics and its uses through the ages. (Such knowledge has both cultural and utilitarian values.)
8. To affiliate with such organizations as promote the study of mathematics on the secondary level and stimulate his professional growth.